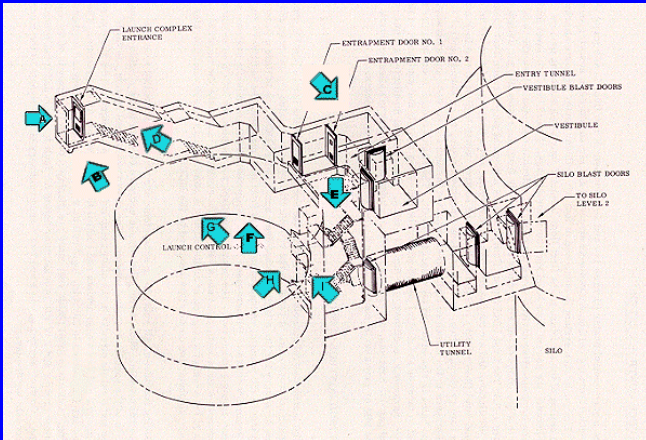


# Former Atlas Missile Site No. 7, Vernon, Texas



## Expanded Site Investigation Report

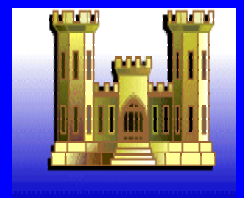
### Report, Appendixes A through J)

January 2001

Total Environmental Restoration Contract  
Contract No. DACA56-94-D-0021  
Task Order No. 22

Prepared by:  
Morrison Knudsen Corporation  
Littleton, Colorado

Prepared for:  
U.S. Army Corps of Engineers  
Tulsa District  
Tulsa, Oklahoma



**FINAL REPORT  
FOR  
EXPANDED SITE INVESTIGATION  
FORMER ATLAS MISSILE SITE NO. 7  
Vernon, Texas**

**Prepared For:**

**U.S. Army Corps of Engineers,  
Tulsa District  
Tulsa, Oklahoma**

**Prepared By:**

**Littleton, Colorado**



**MORRISON KNUDSEN CORPORATION  
Under Contract to:**

**U.S. Army Corps of Engineers  
Tulsa District  
Tulsa, Oklahoma**

**TOTAL ENVIRONMENTAL RESTORATION CONTRACT  
CONTRACT NO. DACA56-94-D-0021**

**January 16, 2001  
Revision 0**

**FINAL REPORT**  
**FOR**  
**EXPANDED SITE INVESTIGATION**

**FORMER ATLAS MISSILE SITE NO. 7**  
**Vernon, Texas**

**Revision 0**

**REVIEWS AND APPROVALS**

\_\_\_\_\_  
Steve Roe, MK Program Manager

\_\_\_\_\_  
Date

\_\_\_\_\_  
Lacy Key, MK Project Manager

\_\_\_\_\_  
Date

**Acceptance:**

\_\_\_\_\_  
Carol Wies  
U.S. Army Corps of Engineers  
Tulsa District

\_\_\_\_\_  
Date

## TABLE OF CONTENTS

| <b><u>Section</u></b>   | <b><u>Page</u></b> |
|---|--------------------|
| ACRONYM LIST .....  | vii                |
| EXECUTIVE SUMMARY.....  | ix                 |
| 1.0 INTRODUCTION.....   | 1-1                |
| 1.1 Site Location and History .....                           | 1-1                |
| 1.2 General Physiography .....                                | 1-1                |
| 1.3 Previous Environmental Investigations and Closures .....  | 1-5                |
| 1.3.1 Investigations .....                                    | 1-5                |
| 1.3.2 Closures .....  | 1-7                |
| 1.4 ESI Study Objective .....                                 | 1-7                |
| 2.0 ESI FIELD INVESTIGATION.....                              | 2-1                |
| 2.1 Field Investigation Overview .....                        | 2-1                |
| 2.2 Sample Analysis Summary .....                             | 2-2                |
| 2.3 Surface Soil Samples.....                                 | 2-5                |
| 2.3.1 Sample Locations .....                                  | 2-5                |
| 2.3.2 Sample Collection Methods.....                          | 2-7                |
| 2.4 Boreholes.....  | 2-7                |
| 2.4.1 Drilling Methods.....                                   | 2-9                |
| 2.4.2 Subsurface Soil Sample Collection.....                  | 2-10               |
| 2.5 Monitoring Wells .....                                    | 2-11               |
| 2.5.1 Well Installation .....                                 | 2-11               |
| 2.5.2 Well Development .....                                  | 2-13               |
| 2.5.3 Groundwater Sampling.....                               | 2-13               |
| 2.5.4 Water Level Measurements.....                           | 2-15               |
| 2.6 Equipment Decontamination .....                           | 2-15               |
| 2.7 Investigative Derived Wastes (IDW) .....                  | 2-15               |
| 2.8 Location Survey .....                                     | 2-16               |
| 3.0 SITE GEOLOGY AND HYDROGEOLOGY .....                       | 3-1                |
| 3.1 Local Physiography, Geology and Underlying Aquifers ..... | 3-1                |
| 3.2 Geology.....  | 3-3                |
| 3.2.1 Seymour Formation .....                                 | 3-3                |
| 3.2.2 San Angelos Formation .....                             | 3-5                |
| 3.3 Hydrogeology.....   | 3-6                |
| 4.0 REGULATORY COMPLIANCE.....                                | 4-1                |
| 5.0 INVESTIGATION RESULTS.....                                | 5-1                |
| 5.1 Surface Soils.....  | 5-2                |
| 5.2 Subsurface Soils .....                                    | 5-4                |
| 5.3 Groundwater .....   | 5-5                |

|       |  |      |
|-------|--|------|
| 5.4   | Preliminary Comparison of ESI Data to RRS1 and RRS2 Cleanup Levels | 5-7  |
| 5.4.1 | Comparison to RRS1.....  | 5-10 |
| 5.4.2 | Comparison to RRS2.....  | 5-10 |
| 6.0   | SUMMARY .....  | 6-1  |
| 6.1   | Geology/Hydrogeology.....  | 6-1  |
| 6.2   | Field Sampling Program.....  | 6-1  |
| 6.3   | Nature and Extent of Contamination .....                           | 6-2  |
| 7.0   | RECOMMENDATIONS.....   | 7-1  |
| 8.0   | REFERENCES.....  | 8-1  |

## **Figures**

|            |   |     |
|------------|---|-----|
| Figure 1-1 | Regional Location Map .....   | 1-2 |
| Figure 1-2 | Area Location Map.....  | 1-3 |
| Figure 1-3 | Site Map Showing On-Site Structures and Former SI Sampling<br>Locations .....                   | 1-4 |
| Figure 2-1 | ESI Surface Soil Sampling Locations.....  | 2-6 |
| Figure 2-2 | ESI Borehole and Monitoring Well Locations.....   | 2-8 |
| Figure 3-1 | Generalized Site Geologic Cross-Section A-A.....  | 3-4 |
| Figure 3-2 | Contoured Potentiometric Surface (Water Table) within Seymour<br>Aquifer (August 14, 2000)..... | 3-7 |

## **Tables**

|           |  |      |
|-----------|--|------|
| Table 1-1 | Summary of Detectable Contaminant Concentrations as Reported<br>in the Site Investigation.....                             | 1-6  |
| Table 2-1 | Sample ID, Depth Interval, Quality Control and Chemical Analysis<br>Performed for Surface and Subsurface Soil Samples..... | 2-3  |
| Table 2-2 | Sample ID, Quality Control and Chemical Analysis Performed for<br>Ground Water Samples .....                               | 2-4  |
| Table 2-3 | Monitoring Well Construction Summary.....  | 2-12 |
| Table 3-1 | Stratigraphy in the Vicinity of the Former AMS No. 7.....  | 3-2  |
| Table 5-1 | Summary of Contaminant Maximum Concentrations and Known<br>Clean-Up Levels for RRS1 and RRS2 (Industrial Scenario) .....   | 5-8  |

## **Plates**

Plate 1        ESI Sampling Locations

## **Appendices**

- A        Sample Collection Logs
  - A.1    Soils
  - A.2    Groundwater
- B        Borehole Logs
- C        Monitoring Well Construction Diagrams and State Well Registrations Forms
- D        Monitoring Well Development Logs
- E        Field Notes
  - E.1    Geologist
  - E.2    Sample Technician
- F        Waste Records
  - F.1    Waste Sample Collection Logs
  - F.2    Waste Disposal Manifests
- G        Location Survey Data
- H        Analytical Summary
  - H.1    Surface Soil Locations
  - H.2    Boreholes
  - H.3    Groundwater
  - H.4    Waste Bins
  - H.5    Reagent Grade II Rinse Water and Liquid Polymer Drilling Additive (Insta-Vis)
- I        Detection Tables
  - I-1    Summary of Organic Compounds Detected in Surface Soils
  - I-2    Compounds Detected in Surface Soils Potentially Associated with Pesticides/Herbicide Spraying
  - I-3    Summary of Metals Detected in Surface Soils
  - I-4    Summary of Organic Compounds Detected in Subsurface Soils at Shallow Boreholes
  - I-5    Summary of Metals Detected in Subsurface Soils at Shallow Boreholes
  - I-6    Organic Compounds, Metals and Inorganics Detected in Groundwater
- J        Site Closure Criteria
  - J.1    TNRCC Risk Reduction Standards
  - J.2    Texas-Specific Background Concentrations
- K        PARCCS Summary (Separate Cover)
- L        Data Validation and Lab Reports (Separate Cover)

## ACRONYM LIST

---

|       |   |
|-------|---|
| AF    | Artificial Fill                                     |
| AMS   | Atlas Missile Site                                  |
| ARARs | Applicable or Relevant and Appropriate Requirements |
| AST   | Above-ground Storage Tank                           |
| ASTM  | American Society of Testing and Materials           |
| bgs   | below ground surface                                |
| CFR   | Code of Federal Regulations                         |
| DI    | Deionized   |
| DOD   | Department of Defense                               |
| DNAPL | Dense Non-aqueous Phase Liquid                      |
| EB    | Equipment Blank                                     |
| EPA   | U.S. Environmental Protection Agency                |
| ESI   | Expanded Site Investigation                         |
| FFA   | Future Farmers of America                           |
| FUDS  | Formerly Used Defense Site                          |
| gpm   | gallons per minute                                  |
| HSA   | Hollow-stem auger                                   |
| ID    | Inside Diameter                                     |
| IDW   | Investigative Derived Waste                         |
| LCC   | Launch Control Center                               |
| LNAPL | Light Non-aqueous Phase Liquid                      |
| MDL   | method detection limit                              |
| MEK   | Methyl Ethyl Ketone                                 |
| MK    | Morrison Knudsen Corporation                        |
| MSC   | Medium Specific Concentration                       |
| msl   | Mean Sea Level                                      |
| NTU   | Nephelometric Turbidity Units                       |
| PA    | Preliminary Assessment                              |
| PCB   | Polychlorinated Biphenyls                           |
| PID   | Photo Ionization Detector                           |
| PQL   | Practical Quantitative Limit                        |
| PVC   | Polyvinyl Chloride                                  |
| QA    | Quality Assurance                                   |
| QC    | Quality Control                                     |
| RCRA  | Resource Conservation and Recovery Act              |
| RRS   | Risk Reduction Standards                            |
| SI    | Site Investigation                                  |
| SOPs  | Standard Operating Procedure                        |
| SOW   | Scope of Work                                       |



|       |   |
|-------|---|
| SVOC  | Semi-volatile Organic Compound                  |
| TAL   | Total Analyte List                              |
| TCE   | Trichloroethene or Trichloroethylene            |
| TCLP  | Toxicity Characteristic Leaching Procedure      |
| TDS   | Total Dissolved Solids                          |
| TERC  | Total Environmental Restoration Contract        |
| THM   | Trihalomethanes                                 |
| TIC   | Tentatively Identified Compound                 |
| TNRCC | Texas Natural Resources Conservation Commission |
| TRPH  | Total Recoverable Petroleum Hydrocarbons        |
| USACE | United States Army Corp of Engineers            |
| USCS  | Unified Soil Classification System              |
| UST   | Underground Storage Tank                        |
| VOC   | Volatile Organic Compound                       |
| WP    | Work Plan                                       |

## EXECUTIVE SUMMARY

---

This Expanded Site Investigation (ESI) was conducted to determine if any releases of hazardous substances occurred at the former Atlas Missile Site (AMS) No. 7 when the Department of Defense occupied the site during 1960 to 1967. The ESI consisted of a

- literature research,
- site inspection
- data collection,
- results and findings presentation, and
- recommendations for site closure and remediation.

Site closure and remediation will adhere to Texas Natural Resources Conservation Commission (TNRCC) Chapter 335, Subchapter S Risk Reduction Standards (RRS). All data was collected closely following TNRCC and U.S. Environmental Protection Agency protocol.

AMS No. 7 is currently owned by a local government (Northside Independent School District No. 905 of Vernon, Texas), and the school district currently uses this facility for livestock shows several times each year. Therefore, non-residential or industrial risk reduction cleanup levels will apply to this site. Exposure pathways identified for this site are groundwater ingestion, soil inhalation/ingestion and groundwater protection with the nearest farm residence located approximately one-quarter mile.

The site investigation focused on three areas that were suspected to have had the greatest potential for contaminant release(s) based on historical or former site activities. These areas were:

1. Incinerator area,
2. Cooling tower area, and
3. Underground diesel fuel storage tank area.

The structures in these areas have been removed; therefore, the investigation was limited to assessing existing soil and groundwater site conditions. Specific field data collected included:

- surface soil samples

- subsurface soil samples from three boreholes, and
- groundwater samples from three shallow wells and one deep well

Surface soil lead and zinc concentrations exceeded Texas-specific background concentrations near the former incinerator and former cooling tower areas and will require localized remediation for compliance with RRS1 or RRS2 cleanup levels described in Appendices J.1 and J.2. Additionally, petroleum vapors, elevated photoionization readings and the detection of trichloroethylene (TCE) near or in monitoring well number 8 indicates a potential contaminant release and should be further evaluated to confirm the TCE concentration. Other metals, VOCs, and SVOCs were detected in surface soils, subsurface soils, and groundwater; however, their concentrations did not exceed RRS2 closure requirements.

In summary, a preliminary comparison of existing ESI data to the TNRCC Risk Reduction Standards indicates that closure to RRS1 and RRS2 does not appear to be achievable without localized soil remediation and groundwater monitoring. Localized remediation would include removal of localized surface soil contamination near the former incinerator and former cooling towers. All groundwater monitoring wells would be monitored for TCE to determine the viability of attenuation of TCE or the need for localized groundwater treatment. Closure to RRS2 may be required if low levels of TCE persist in groundwater around the cooling towers. Therefore, regulatory input is encouraged to ensure site closure and remediation efforts are consistent with TNRCC closure and remediation requirements.

## **1.0 INTRODUCTION**

---

### **1.1 Site Location and History**

The entire Formerly Used Defense Site (FUDS) property covers approximately 8 acres in an area of farmland; however, the missile silo and its support buildings were located in a secured and fenced area comprising less than 5 acres, located approximately five miles south of the Texas-Oklahoma border, shown in Figure 1-1. The site is accessed by State Highway 91, as shown in Figure 1-2. The nearest residential community is Odell, Texas, located approximately 6 miles west of the project site.

Prior to construction of the missile launch facility, the site was used primarily for cattle grazing and cattle operations. The site was selected by the Department of Defense (DOD) because of its isolation in an unpopulated, rural area of the state, and acquired in March 1960. The site was attached to the Altus Air Force Base. Construction of the facility was completed shortly thereafter. Site improvements made by the DOD included a Quonset hut, an underground Launch Control Center (LCC), an underground missile silo, septic systems, underground storage tank (UST), water supply well with pump house, helicopter pad, and various utility vaults/manholes (Figure 1-3).

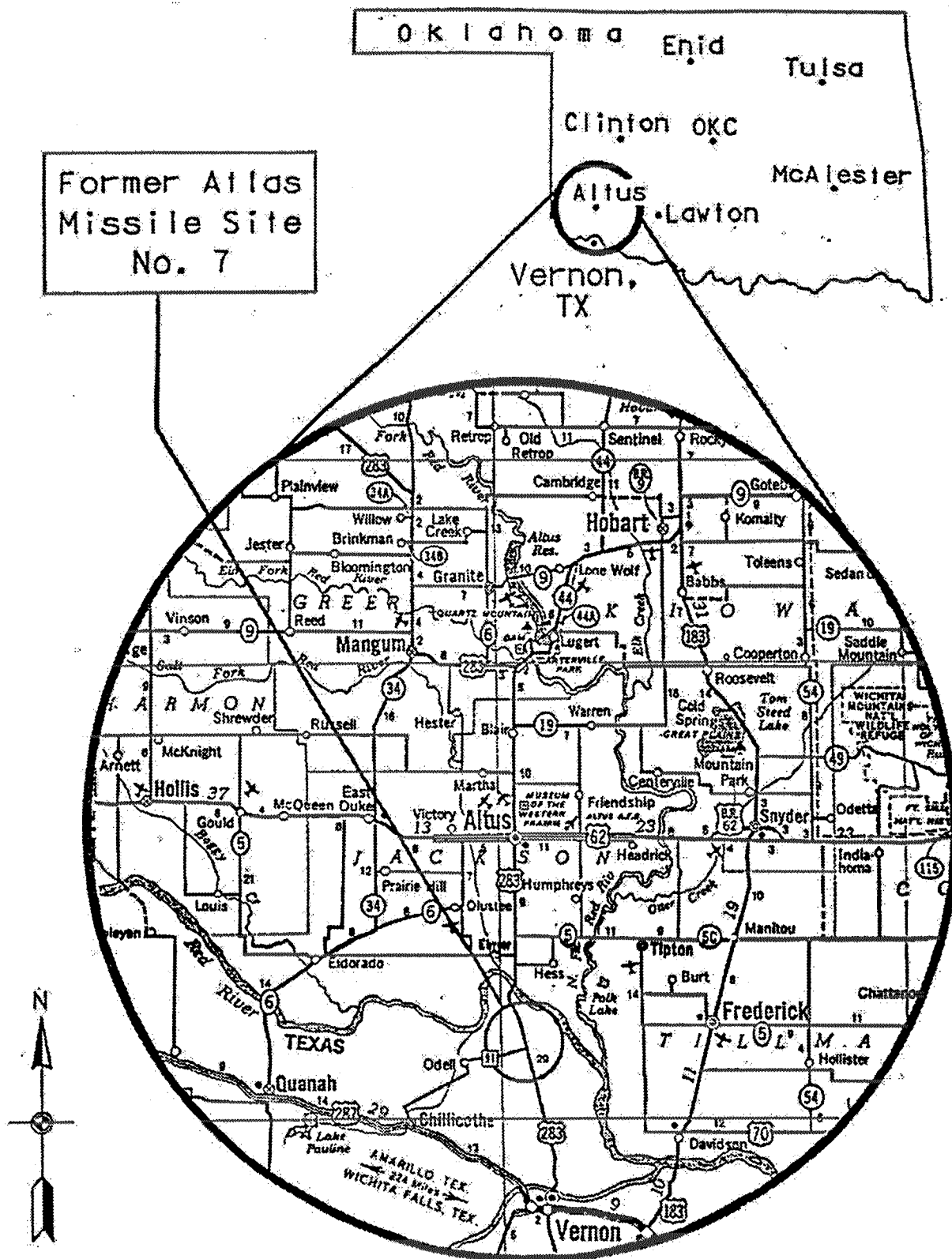
The missile site was active for only a short period of time while housing liquid rocket propelled missiles with single nuclear warheads before being taken out of service in 1964. The site was later identified as excess, and the property was conveyed by deed to the Northside Independent School District No. 905, Vernon, Texas, in 1967. The DOD removed all USTs prior to conveyance of the property to the school district. The school district has since used the facility for Future Farmers of America (FFA) exhibitions and other livestock shows.

### **1.2 General Physiography**

The AMS No. 7 is located in gently rolling topography of northwestern Wilbarger County known as the Odell Sand Hills (Willis and Knowles, 1953). The site has as an average elevation of 1365 feet above mean sea level (msl). The area is predominantly sandy soils with the primary groundwater aquifer located approximately 20 feet below ground surface.

More detailed discussion of the physiography, geology, and underlying aquifers are found in Section 4.0.

Former Atlas  
Missile Site  
No. 7



TULSA TERC  
ESI REPORT  
FORMER AMS NO. 7

Figure 1-1

REGIONAL LOCATION  
MAP



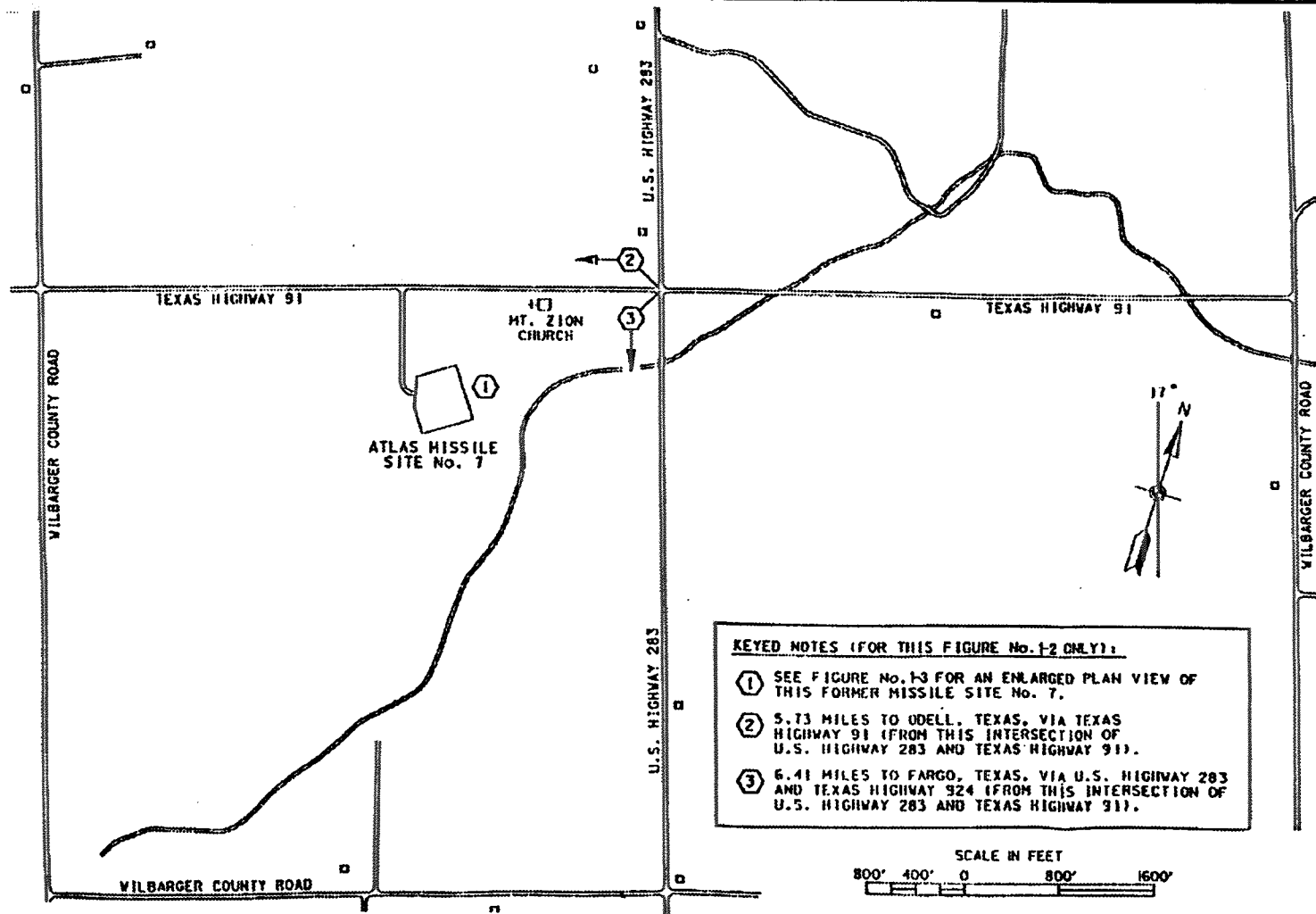
USACE TULSA DISTRICT



MORRISON KNUDSEN CORPORATION

|                 |             |         |            |
|-----------------|-------------|---------|------------|
| FILE NAME (CAD) | 2201018.dwg | DATE    | 05/02/00   |
| WORK ORDER      | 4423        | TASK    | 0220       |
| DRAWING NUMBER  |             | 2201018 | REV. DRIVE |
|                 |             |         | A          |

<CPD: 05/02/00 [TIME: 5:43 PM]>



**KEYED NOTES (FOR THIS FIGURE No. 1-2 ONLY):**

- ① SEE FIGURE No. 1-3 FOR AN ENLARGED PLAN VIEW OF THIS FORMER MISSILE SITE No. 7.
- ② 5.73 MILES TO ODELL, TEXAS, VIA TEXAS HIGHWAY 91 (FROM THIS INTERSECTION OF U.S. HIGHWAY 283 AND TEXAS HIGHWAY 91).
- ③ 6.41 MILES TO FARGO, TEXAS, VIA U.S. HIGHWAY 283 AND TEXAS HIGHWAY 924 (FROM THIS INTERSECTION OF U.S. HIGHWAY 283 AND TEXAS HIGHWAY 91).

SCALE IN FEET  
800' 400' 0 800' 1600'

TULSA TERC  
ESI REPORT  
FORMER AMS NO. 7

Figure 1-2

AREA LOCATION MAP



USACE TULSA DISTRICT

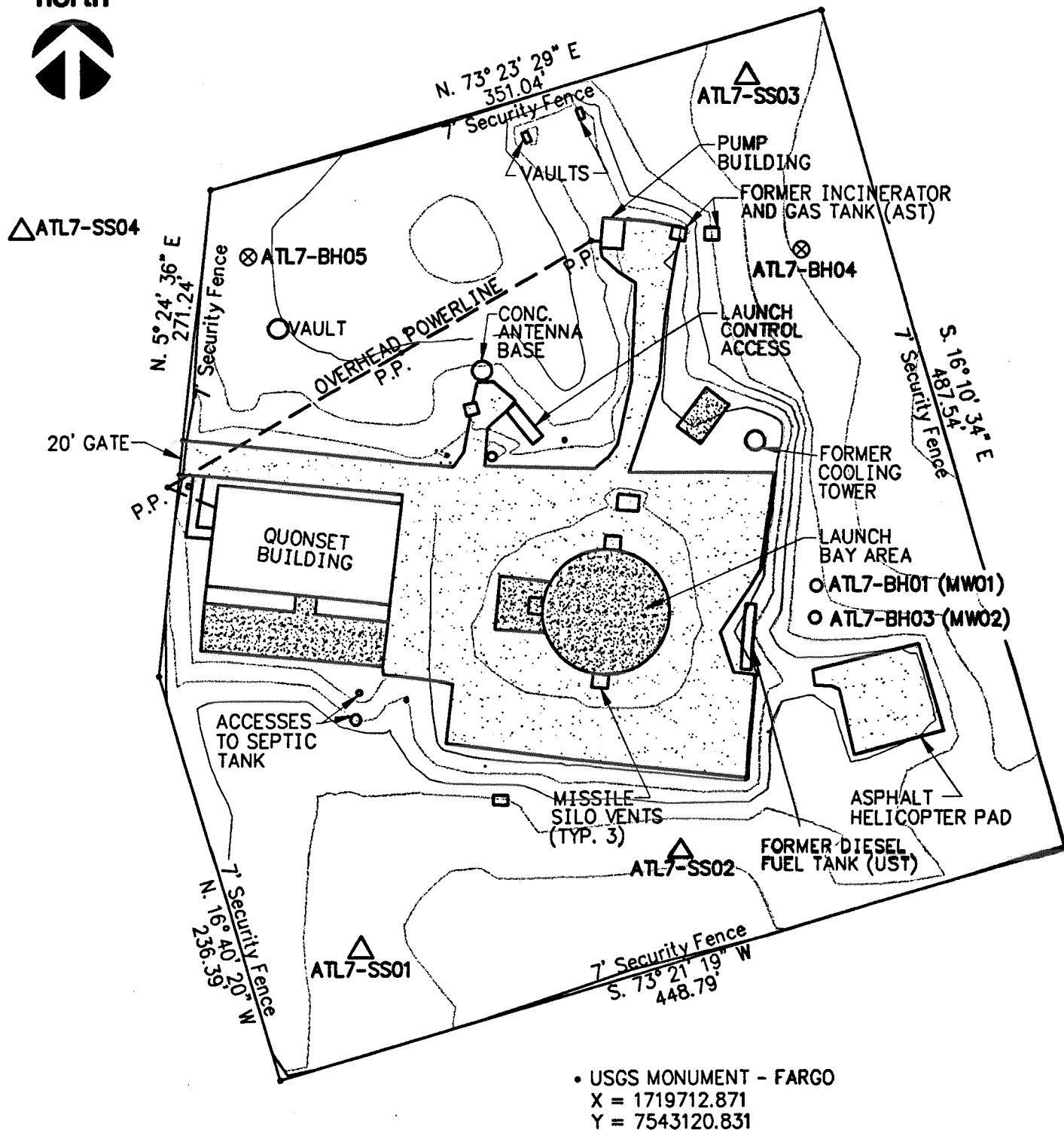


MORRISON KNUDSEN CORPORATION

|                 |             |      |          |
|-----------------|-------------|------|----------|
| FILE NAME (CAD) | 2201019.dwg | DATE | 05/02/00 |
| WORK ORDER      | 4423        | TASK | 0220     |
| DRAWING NUMBER  | 2201019     | REV. | A        |

Source: USACE, 1998

north



• USGS MONUMENT - FARGO  
X = 1719712.871  
Y = 7543120.831

## LEGEND

- △ SURFACE SAMPLE
- ⊗ BOREHOLE
- BOREHOLE/MONITORING WELL
- CONCRETE
- ASPHALT

NOTE: ALL BEARINGS AND DISTANCES ARE STATE PLANE GRID VALUES.

|  |             |       |          |
|--|-------------|-------|----------|
| TULSA TERC<br>ESI REPORT<br>FORMER AMS NO. 7   |             |       |          |
| Figure 1-3<br>SITE MAP SHOWING ON-SITE<br>STRUCTURES AND<br>FORMER SI SAMPLING LOCATIONS |             |       |          |
| USACE TULSA DISTRICT   |             |       |          |
| MORRISON KNUDSEN CORPORATION   |             |       |          |
| FILE NAME (CAD)  | 2201020.dwg | DATE  | 05/02/00 |
| WORK ORDER   | 4423        | TASK  | 0220     |
| DRAWING NUMBER   | 2201020     | REV.  | A        |
|  |             | DRIVE |          |

CPD: 05/08/00 [TIME: 4:35 PM]

### **1.3 Previous Environmental Investigations and Closures**

Previous work at this site consisted of a Preliminary Assessment and Site Inspection (PA/SI) conducted during 1995, and closure of various DOD structures onsite during 1999.

#### **1.3.1 Investigations**

The PA/SI for the AMS No.7 was conducted in 1995 by the USACE as part of the DOD Environmental Restoration Program (USACE, 1998). The primary objectives of the PA/SI were to determine if there was a potential for release of hazardous substances due to DOD activities at the site.

The PA was accomplished by gathering and reviewing existing information from:

- site interviews,
- DOD files,
- published geological and hydrogeological reports, and
- aerial photography.

The PA identified sources for potential releases as:

1. on-site fuel tanks used to fuel electrical generators and incinerators,
2. fuels and oils used for equipment maintenance, and
3. the hydraulic system used to operate the launch bay doors.

The purpose of the SI that followed the PA was to investigate if contamination of site soils or groundwater had occurred as a result of past DOD activities and what present threat exists to human health and/or the environment, if a release had occurred. SI activities consisted of the following:

- Collection of surface soil samples.
- Installation of three shallow boreholes for surface and subsurface soils data collection.
- Installation of a shallow and a deep well to assess ground water quality.
- Collection of water samples from the flooded missile silo and from an on-site water well via a water spigot.



Surface soils, subsurface soils and water were analyzed for volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), total recoverable petroleum hydrocarbons (TRPH), and the eight Resource Conservation and Recovery Act (RCRA) metals. SI sampling locations are shown on Figure 1-3.

## SI Findings and Recommendations

No VOCs were detected in soil or groundwater and all metals detected were stated as within acceptable background ranges. TRPH and several SVOCs were detected in soils and groundwater and are summarized below in Table 1-1.

**Table 1-1 Summary of Detectable Contaminant Concentrations as Reported in the Site Investigation**

| Compound  | Surface Soil   |              | Subsurface Soil |               | Groundwater |               |
|---|----------------|--------------|-----------------|---------------|-------------|---------------|
|   | Detected       | Conc (µg/kg) | Detected        | Conc. (µg/kg) | Detected    | Conc. (µg/l)  |
| Total Recoverable Petroleum Hydrocarbon   | 1 in 7 samples | 4180         | None            |               | 2 of 2      | 0.55 and 1.56 |
| Bis(2-ethylhexyl) phthalate   | 5 of 7 samples | 390 to 807   | 11 of 13        | 416 to 7,870  | 2 of 2      | 28.9 and 93.3 |
| Benzoic Acid  | None           |              | None            |               | 1 of 2      | >176          |
| Di-n-octylphthalate   | None           |              | None            |               | 1 of 2      | 16.2          |
| Phenol  | None           |              | None            |               | 1 of 2      | 13.2          |
| Source: Site Inspection Final Report, Atlas Missile Site No. 7, Wilbarger County, Texas, Project No. K06TX006302, February 1998, US Army Corps of Engineers, Tulsa District |                |              |                 |               |             |               |

Bis(2-ethylhexyl)phthalate was the only SVOC detected in soils. It was detected at all three boreholes and occurred at depths ranging from the surface to 25 feet below ground surface (bgs). SVOCs detected in groundwater included bis(2-ethylhexyl)phthalate, benzoic acid, di-n-octylphthalate, and phenol.

Bis(2-ethylhexyl)phthalate is commonly added to plastics to enhance flexibility, therefore the SI report concluded that the presence of this compound in site soils and groundwater was probably due to leaching of the compound from sampling equipment and rubber gloves used in sampling, rather than a result of former DOD activities onsite. The report also stated that the other SVOCs detected in groundwater were known laboratory contaminants and were thought to be probably introduced during laboratory procedures. Based on these conclusions, the SI report recommended no further action

at the site. In May of 1998, the monitoring wells at the site were plugged and abandoned.

In March of 1999, the Texas Natural Resource Conservation Commission (TNRCC) completed its review of the SI Report and responded with a Notice of Deficiency, disagreeing that the presence of SVOC contaminants were not field sampling or laboratory artifact and that potential impacts to the upper and lower aquifers had not been properly evaluated.

### **1.3.2 Closures**

In late 1999, the USACE (Tulsa District) completed the following site closure activities (MK, 2000a):

- The underground silo and LCC were backfilled with flowable fill,
- The above ground portion of the LCC stairwell entrance and other utility risers and vents were demolished below grade and then covered with clean fill to prohibit future access,
- The silo launch bay doors were welded shut, and
- The site was graded and reseeded.

### **1.4 ESI Study Objective**

The main objective of the Expanded Site Investigation (ESI) was to collect information that was not obtained and reported during a previous investigation report and to provide sufficient information to substantiate compliance with one of three risk reduction standards (RRS) as it relates to site closure and remediation.

The TNRCC in their Notice of Deficiency dated March 5, 1999 outlined the following issues, concerns, and comments that were considered in developing specific study objectives for completing this ESI:

1. Removal or decontamination of all contaminated media or operating system components to background concentrations is necessary to attain RRS 1 site closure. Contaminants exceeding background concentrations may be allowed for RRS 2 and RRS 3; however, deed certification or deed recordation in Wilbarger County deed records is necessary.
2. Present and interpret all collected data, to the extent possible.

3. Conduct all sampling in accordance with proper TNRCC and U.S. Environmental Protection Agency (EPA) procedures.
4. Metals analyzes should include all metals listed in 40 CFR, Part 264, Appendix IX and not just the eight RCRA metals noted in 40 CFR Part 261.23.
5. Use the lowest possible limits of quantitation in laboratory analyses.
6. Designate and substantiate whether residential or nonresidential cleanup standards apply.
7. Test the groundwater to the full depth of the missile silo.
8. Test for dense non-aqueous phase liquids (DNAPL) at the sediment-bedrock interface.
9. Test for light non-aqueous phase liquids (LNAPL) across the top of the water table encountered at 14 to 16 feet below ground surface.
10. Determine if uppermost aquifer is continuous to the entire depth of the silo.
11. Identify the distinct saturated zones to the depth of the silo.
12. Discuss whether the missile silo is the only potential ground water source or if other potential contaminant sources should be evaluated, such as the underground storage tank.
13. Determine local groundwater flow direction by measuring the water table at a minimum of three locations.
14. Consider all data collected regardless if the contaminant(s) is regulated.
15. Provide a thorough description of the water wells to include their present status, location, static water elevations, construction, production interval, and any sampling results.

The USACE required specific objectives be addressed while completing this comprehensive ESI Report as well as address TNRCC concerns noted above. Specific investigation objectives included:

1. Characterize the contamination at the site
2. Gather field data to evaluate the level of concentrations and their associated risks/threat
3. Identify potential pathways of exposure
4. Identify applicable regulatory requirements
5. Establish which Texas RRS is achievable
6. Determine if additional work is required
7. Identify additional work requirements
8. Identify costs associated with the additional work.

## **2.0 ESI FIELD INVESTIGATION**

---

This section describes the activities and general procedures performed during the field investigation. The field investigation was performed by MK and its subcontractors from July 12 to August 14, 2000. A detailed description of procedures and specifications are contained within the final ESI Work Plan (WP) and included standard operating procedures (SOPs) (MK, 2000b).

Supporting documentation is presented in the following appendices:

- Sample collection logs and borehole logs are presented in Appendix A and B, respectively.
- Monitoring well construction diagrams and state well registration forms are presented in Appendix C.
- Monitoring well development logs are presented in Appendix D.
- Field notes, waste records, and location survey data are presented in Appendices E through G, respectively.

### **2.1 Field Investigation Overview**

The ESI field investigation program consisted of the following activities as stipulated in the Scope of Work Expanded Site Investigation Former Atlas Missile Site No. 7, Vernon, Texas, Contract No. DACA56-94-D-0021, Modification 2211, hereafter known as the Scope of Work (SOW):

- Collection of ten (10) surface soil samples (seven on-site and three off-site) for chemical analysis.
- Drilling and continuous coring of three shallow boreholes. Boreholes were drilled to the top of the alluvial/bedrock contact and soils were lithologically described. Soil samples were collected for chemical analysis at 5-foot intervals within the vadose zone at each borehole and at the underlying alluvial/bedrock contact.

- Drilling and continuous coring of one deep borehole. The deep borehole was drilled to 210 feet bgs and soils were lithologically described. No soil samples were collected for chemical analysis as directed in the SOW.
- Subsequent installation of monitoring wells at each borehole location. Shallow wells were screened across the water table within the Seymour Aquifer to test for dissolved phase contaminants and light non-aqueous phase liquid (LNAPL). The deep bedrock well was screened at the bottom of the borehole to test for dissolved phase contaminants in the San Angelos Aquifer below the former missile silo base. Well installation was followed by well development and groundwater sampling at each well.
- Location surveying of all sampling locations and monitoring wells.

## **2.2 Sample Analysis Summary**

All soil samples collected were analyzed for VOCs, SVOCs, pesticides/herbicides, polychlorinated biphenyls (PCBs), TRPH, and total analyte list (TAL) of metals as listed in 40 CFR, Part 264, Appendix IX. Soil sample analyses were performed by Test America, Inc., Nashville, Tennessee.

Groundwater samples were analyzed for TNRCC Drinking Water Standard parameters and TRPH. TNRCC Drinking Water Standards include VOCs, trihalomethanes (THM), SVOCs, insecticides/herbicides, carbamate insecticides, organohalide pesticides, PCBs, endothall, glyphosate, diquate, metals, fluoride, cyanide, and nitrate/nitrite. Groundwater sample analyses were performed by Environmental Health Laboratories, Southbend, Indiana.

Quality Control and Quality Assurance (QA/QC) samples were collected for soil and groundwater samples at a frequency of one per ten samples (10 percent). Equipment blank (EB) samples were collected at a frequency of one per twenty samples (5 percent) for both soil and groundwater. QA/QC and EB samples are listed in Table 2-1 and Table 2-2. Laboratory prepared trip blanks were included and analyzed for each cooler containing aqueous samples for VOC analysis. QA sample analyses were performed by the USACE contract laboratories.

Table 2-1

**Sample ID, Depth Interval, Quality Control and Chemical Analysis Performed for  
Surface and Subsurface Soil Samples  
AMS No. 7 ESI**

| <b>Sample ID<br/>(AMS7-)</b> | <b>Depth Interval<br/>(ft)</b> | <b>Quality Control</b> | <b>VOCs<br/>(EPA 5035/8260)</b> | <b>SVOCs<br/>(EPA 8270)</b> | <b>Pesticides<br/>(EPA 8081)</b> | <b>PCBs<br/>(EPA 8082)</b> | <b>Herbicides<br/>(EPA 8151)</b> | <b>TPH<br/>(TNRCC 1005)</b> | <b>Total Metals <sup>1</sup><br/>(EPA 6000/7000)</b> |
|------------------------------|--------------------------------|------------------------|---------------------------------|-----------------------------|----------------------------------|----------------------------|----------------------------------|-----------------------------|--|
|------------------------------|--------------------------------|------------------------|---------------------------------|-----------------------------|----------------------------------|----------------------------|----------------------------------|-----------------------------|--|

**Surface Soil Samples**

|       |           |       |   |   |   |   |   |   |   |
|-------|-----------|-------|---|---|---|---|---|---|---|
| SS-05 | 0.0 - 0.5 |       | X | X | X | X | X | X | X |
| SS-06 | 0.0 - 0.5 | EB    | X | X | X | X | X | X | X |
| SS-07 | 0.0 - 0.5 |       | X | X | X | X | X | X | X |
| SS-08 | 0.0 - 0.5 | QA/QC | X | X | X | X | X | X | X |
| SS-09 | 0.0 - 0.5 |       | X | X | X | X | X | X | X |
| SS-10 | 0.0 - 0.5 |       | X | X | X | X | X | X | X |
| SS-11 | 0.0 - 0.5 |       | X | X | X | X | X | X | X |
| SS-12 | 0.0 - 0.5 |       | X | X | X | X | X | X | X |
| SS-13 | 0.0 - 0.5 |       | X | X | X | X | X | X | X |
| SS-14 | 0.0 - 0.5 |       | X | X | X | X | X | X | X |

**Borehole Soil Samples**

|             |             |       |   |   |   |   |   |   |   |
|-------------|-------------|-------|---|---|---|---|---|---|---|
| <b>BH06</b> |             |       |   |   |   |   |   |   |   |
| S-00        | 0.0 - 0.5   |       | X | X | X | X | X | X | X |
| S-05        | 5.0 - 6.0   |       | X | X | X | X | X | X | X |
| S-10        | 10.0 - 11.0 |       | X | X | X | X | X | X | X |
| S-18        | 16.0 - 18.0 | QA/QC | X | X | X | X | X | X | X |
| S-76        | 75.5 - 76.5 |       | X | X | X | X | X | X | X |
| <b>BH07</b> |             |       |   |   |   |   |   |   |   |
| S-00        | 0.0 - 0.5   |       | X | X | X | X | X | X | X |
| S-05        | 5.0 - 6.0   |       | X | X | X | X | X | X | X |
| S-10        | 10.0 - 11.0 |       | X | X | X | X | X | X | X |
| S-85        | 84.5 - 85.5 |       | X | X | X | X | X | X | X |
| <b>BH08</b> |             |       |   |   |   |   |   |   |   |
| S-00        | 0.0 - 0.5   |       | X | X | X | X | X | X | X |
| S-05        | 5.0 - 6.0   |       | X | X | X | X | X | X | X |
| S-10        | 10.0 - 11.0 |       | X | X | X | X | X | X | X |
| S-15        | 15.0 - 16.0 |       | X | X | X | X | X | X | X |
| S-18        | 16.5 - 18.5 | QA/QC | X | X | X | X | X | X | X |
| S-80        | 80.1 - 80.5 | EB    | X | X | X | X | X | X | X |

1 - Metals include: Aluminum, Antimony, Arsenic, Barium Beryllium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Potassium, Selenium, Silver, Sodium, Strontium, Thallium, Tin, Titanium, Vanadium, Zinc, Mercury.

**Table 2-2**

**Sample ID, Quality Control and Chemical Analysis Performed  
for Ground Water Samples  
AMS No. 7 ESI**

| <b>Sample ID<br/>(AMS7-)</b> | <b>Field<br/>Quality<br/>Control</b> | <b>VOCs/<br/>THMs<br/>(EPA 524.2/<br/>504.1)</b> | <b>SVOCs/<br/>Insecticides/<br/>Herbicides<br/>(EPA 525.2/<br/>515.1)</b> | <b>Carbamate<br/>Insecticides<br/>(EPA 531.1)</b> | <b>Organohalide<br/>Pesticides/<br/>PCBs<br/>(EPA 505)</b> | <b>Endothall<br/>(EPA 548.1)</b> | <b>Glyphosate<br/>(EPA 547)</b> | <b>Diquate<br/>(EPA 549.1)</b> | <b>TPH<br/>(TNRCC<br/>1005)</b> | <b>Metals<sup>1</sup><br/>(EPA<br/>200.8)</b> | <b>Inorganics<sup>2</sup></b> |
|------------------------------|--------------------------------------|--|---|---|--|----------------------------------|---------------------------------|--------------------------------|---------------------------------|---|-------------------------------|
| MW06-GW                      | QA/QC                                | X  | X   | X   | X  | X                                | X                               | X                              | X                               | X   | X                             |
| MW07- GW                     | EB                                   | X  | X   | X   | X  | X                                | X                               | X                              | X                               | X   | X                             |
| MW08-GW                      |                                      | X  | X   | X   | X  | X                                | X                               | X                              | X                               | X   | X                             |
| MW09-GW                      |                                      | X  | X   | X   | X  | X                                | X                               | X                              | X                               | X   | X                             |

<sup>1</sup>Metals include Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Mercury, Nickel, Selenium, Thallium, Copper, and Lead.

<sup>2</sup>Inorganics include fluoride by Technicon 380-75WE, cyanide by EPA 335.4, nitrate by EPA 300.0, and nitrite by EPA 353.2.



## **2.3 Surface Soil Samples**

Ten surface soil samples (SS05 through SS14) were collected for chemical analysis. Three surface soil samples (SS05, 06, and 07) were collected outside the perimeter fence or offsite and seven surface soil samples (SS08 through SS14) were collected within the sites perimeter fence or onsite of the AMS No. 7. The three off-site surface soil samples were intended as background samples for comparison purposes with onsite samples. Sample identifications, depth intervals and chemical analyses are summarized in Table 2-1.

### **2.3.1 Sample Locations**

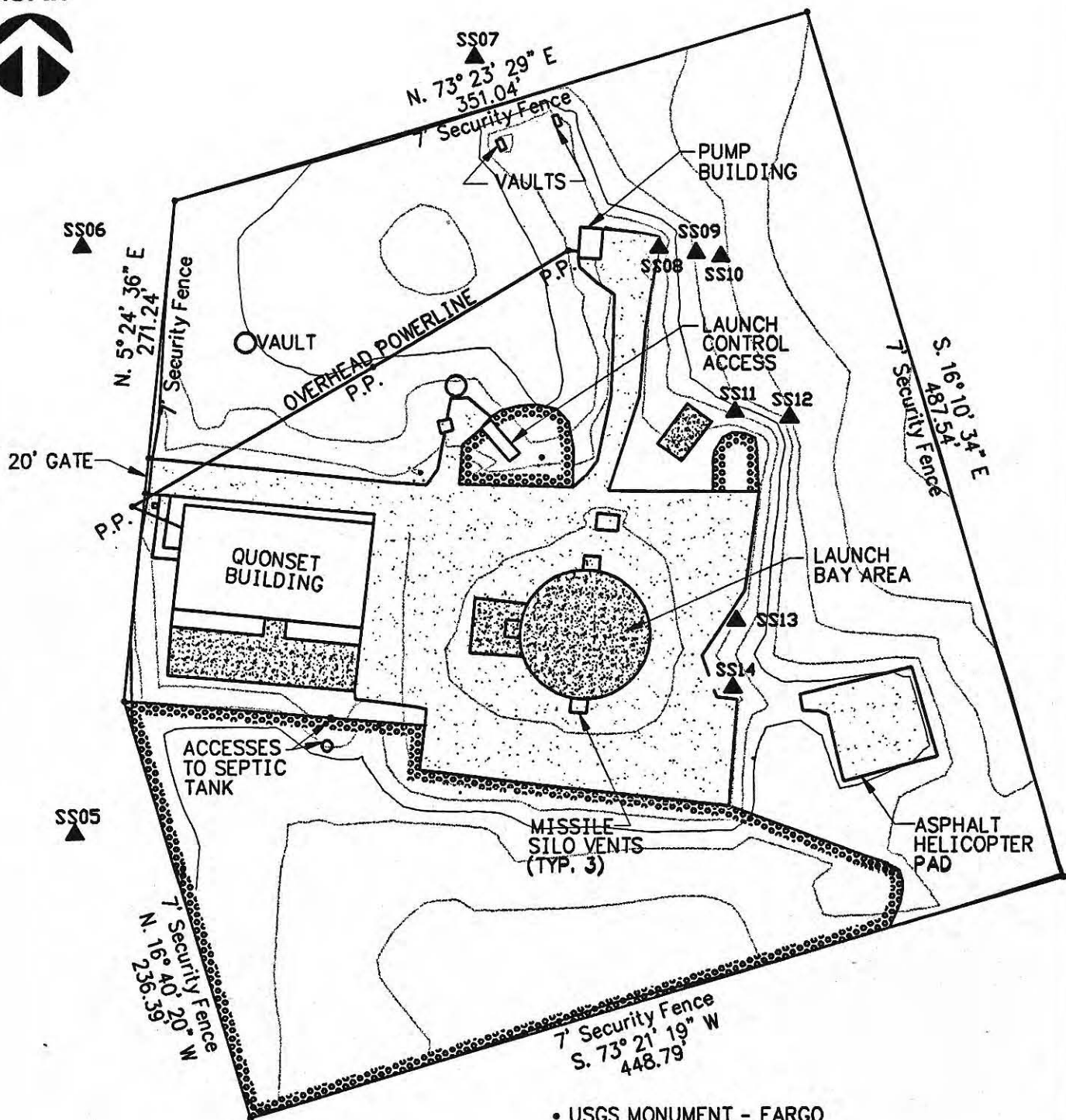
During earlier closure activities in 1999 (MK, 2000a), various sectors of the site were covered with clean imported fill from a local quarry. The fill was used for backfilling structures that were demolished or plugged below grade and was also used as aggregate in the flowable fill. On April 14, 2000, the USACE and MK jointly inspected the site in order to assess site conditions and determine sample locations for the ESI. During the site visit, the areas covered by clean fill were located and are shown on Figure 2-1. Since the near surface soils in these areas consist of clean imported fill, no contamination is expected. A surface soil sample collected from BH-06 confirms this condition.

No evidence of surface spills such as stressed vegetation or discolored soils were identified during the site visit and no surface contaminant releases were found recorded or documented for the site (USACE 1998). Therefore, on-site surface soil locations were located near three former site structures or operations that may have had a potential for contaminants release. The three former site structures or operational areas included:

- Incinerator (surface soil samples SS08, SS09, and SS10)
- Cooling tower (surface soil samples SS11 and SS12)
- Underground diesel storage tank (surface soils samples S13 and SS14)

Sample locations are shown on Figure 2-1 and Plate 1.

north



• USGS MONUMENT - FARGO  
X = 1719712.871  
Y = 7543120.831

## LEGEND

▲ ESI SURFACE SOIL SAMPLE (AMS7- )

PERIMETER OF CLEAN FILL

CONCRETE

ASPHALT

NOTE: ALL BEARINGS AND DISTANCES ARE  
STATE PLANE GRID VALUES.

TULSA TERC  
ESI REPORT  
FORMER AMS NO. 7

Figure 2-1

ESI SURFACE SOIL  
SAMPLE LOCATIONS



USACE TULSA DISTRICT



MORRISON KNUDSEN CORPORATION

FILE NAME (CAD) 2201021.dwg

DATE: 05/02/00

WORK ORDER

TASK

DRAWING NUMBER

REV. DRIVE

4423

0220

2201021

B

<CPO: 09/11/00 [TIME: 4:44 PM]>

### **2.3.2 Sample Collection Methods**

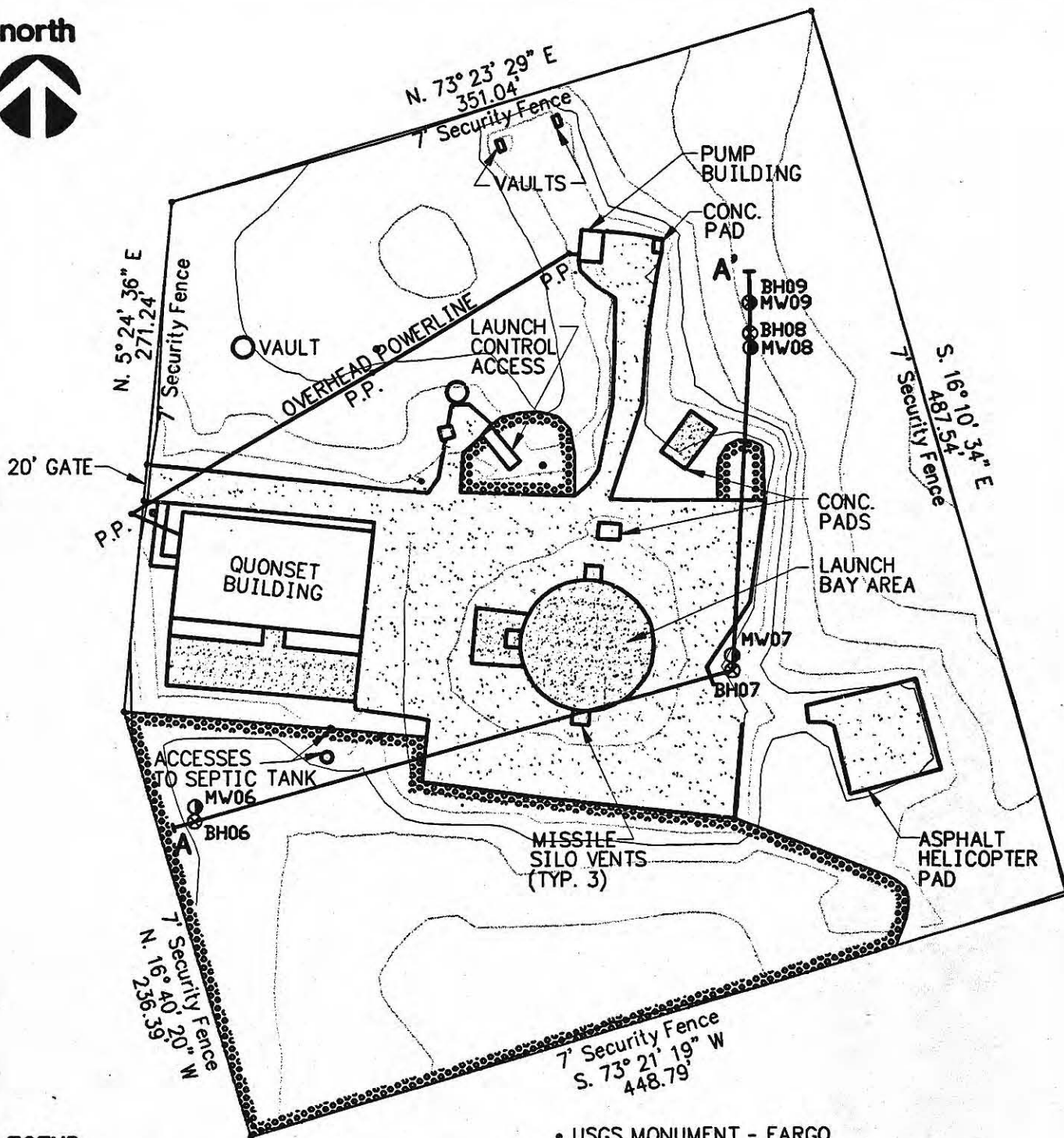
Prior to sampling at each surface soil location, the immediate area was cleared of debris, rocks and vegetation. Five (5) gram soil volumes for VOC analysis were collected using EnCore™ samplers. EnCore™ samplers were pushed directly into surface soils and then soils were transferred immediately into laboratory-preserved sample vials in accordance with EPA Method 5035. Sample volumes for the other analytical parameters were then collected from the upper 6 inches of soil using a stainless steel trowel and placed directly into sample containers without compositing. Sampling information was documented on soil sample collection logs (see Appendix A.1). For QA/QC samples, soil for non-VOC analysis were placed into a stainless steel bowl and homogenized prior to splitting into sample containers.

### **2.4 Boreholes**

Three shallow boreholes (BH06 - BH08) were drilled to investigate the lithologies and potential contamination within the alluvial Seymour Formation or shallow aquifer. The boreholes were drilled and soils continuously cored to the underlying alluvial/bedrock contact. This contact was approximately 80 feet bgs at all three locations. One deep borehole (BH09) was drilled to investigate the lithologies of the underlying San Angelos Formation (bedrock) or deep aquifer. This borehole was drilled to a depth of 210 feet bgs. Monitoring wells were subsequently installed at all four borehole locations.

Borehole (and the subsequent monitoring well) locations were chosen based on areas of potential releases and the presumed groundwater gradient beneath the site. Since the previous SI did not determine the groundwater gradient beneath the site, the gradient was estimated from regional maps for years 1951 through 1971 for the Odell Sand Hills (Price 1979). Based on these maps, groundwater flow may vary from slightly east of north to eastward in the vicinity of the site. BH06 was placed along the southwestern boundary of the site and was assumed to be in an upgradient position. BH07 was placed at the former location of the diesel fuel UST and BH08 was placed down-gradient of the missile silo and former cooling tower location to investigate for potential contaminant releases. BH09 was placed adjacent to BH08 to compare hydrogeologic conditions between the shallow aquifer and the deep aquifer. Borehole locations are shown in Figure 2-2 and Plate 1.

north



## LEGEND

- ⊗ ESI SHALLOW BOREHOLE (AMS7- )
- ESI SHALLOW MONITORING WELL (AMS7- )
- ESI DEEP BOREHOLE/  
MONITORING WELL (AMS7- )

A A'  
— LOCATION OF GEOLOGIC X-SECTION A-A'  
(SEE FIGURE 3-1)

- PERIMETER OF CLEAN FILL
- CONCRETE
- ASPHALT

NOTE: ALL BEARINGS AND DISTANCES ARE  
STATE PLANE GRID VALUES.

• USGS MONUMENT - FARGO  
X = 1719712.871  
Y = 7543120.831

TULSA TERC  
ESI REPORT  
FORMER AMS NO. 7

Figure 2-2

## ESI BOREHOLE AND MONITORING WELL LOCATIONS



USACE TULSA DISTRICT



MORRISON KNUDSEN CORPORATION

FILE NAME (CAD) 2201021a.dwg

DATE: 05/02/00

WORK ORDER  
4423

TASK  
0220

DRAWING NUMBER  
2201021A

REV. DRIVE  
B

### 2.4.1 Drilling Methods

Shallow boreholes were drilled with conventional hollow-stem auger (HSA) methods in combination with a 5-foot-long split sampling barrel that is advanced with the auger string during drilling to obtain continuous samples. At BH07, drive sampling with a two-foot split-spoon was also used in the lower portion of the borehole. Shallow boreholes were drilled with a Longyear BK-81 drill rig.

At each shallow borehole, loose flowing sands were encountered at a depth of about 40 feet bgs. Sand inflow into the augers caused problems in auger drilling and sample barrel retrieval. At borehole BH07, sand flowing into the augers locked the sample barrel in the augers on two separate occasions, requiring the augers and rods to be removed from borehole to retrieve the sample barrel. In attempts to control the inflow of sand at BH07, a water head was added to the augers and circulated through a mud pit. At about 65 feet bgs, a mud additive (Insta-Vis) was added in attempts to remove sand and fines from the augers and stabilize the borehole walls. Insta-Vis (a CETCO product) is a liquid polymer consisting of a surfactant dispersed in a mineral oil base. Therefore, soil samples collected for total petroleum hydrocarbons (TPH) or other organics after the use of Insta-Vis may likely be compromised and were not analyzed for petroleum hydrocarbons. Insta-Vis was not used in the other two shallow boreholes (BH06 and BH08); but pure bentonite mud was added to the inside of the augers during drilling to control the inflow of sand. After completion of each borehole, the augers were removed and borehole abandoned in accordance with state regulatory requirements using a bentonite cement grout.

At the deep borehole (BH-09), an 8-inch-diameter steel isolation casing was cemented in place across the Seymour aquifer prior to drilling ahead into the underlying San Angelos aquifer. Bentonite based mud was used for casing installation and for bedrock coring. The base of the casing was set at 91 feet bgs (7 feet into unweathered bedrock). The casing was set with a Garner-Denver 1500 drill rig using bentonite mud rotary techniques. The San Angelos formation (bedrock) was then continuously cored with a Longyear BK-81 drill rig using conventional air rotary and bentonite mud rotary methods. Rock cores were retrieved with a 10-foot-long inner core barrel attached to a wire-line.

## **Lithologic Logging**

At all borehole locations, alluvium and bedrock was lithologically described by the field geologist. Unconsolidated material (alluvium) was classified in accordance with the American Standard for Testing and Materials (ASTM) Standard D2488-90, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*. This procedure is a modification of the Unified Soil Classification System (USCS). Lithologic descriptions, field observations, sample information, and drilling methods were recorded on borehole log forms and are presented as Appendix B.

### **2.4.2 Subsurface Soil Sample Collection**

Fifteen (15) soil samples were collected for chemical analysis from the three shallow boreholes located within 10 feet of the monitoring wells. Samples were collected to investigate potential contamination within the vadose zone of the Seymour Aquifer and at the underlying alluvial/bedrock contact. Samples for chemical analysis were not collected from the deep borehole. Sample identifications, depth intervals and chemical analysis summaries are presented in Table 2-1. The boreholes were later abandoned in accordance with state regulatory requirements using a bentonite cement grout.

### **Soil Sample Depths**

Samples were collected within the vadose zone from the three shallow boreholes at approximately 5-foot intervals beginning at the land surface and every five foot thereafter until the water table was encountered. The borehole was then advanced (with continuous coring and lithologic logging) until the underlying San Angelos bedrock was encountered. At all three shallow borehole locations, the alluvial/bedrock contact was sharp and distinct, with light brown soft clean sand (SP) overlying reddish brown hard sandstone. The alluvial sand directly above the bedrock contact was then sampled in each borehole to determine the presence or absence of DNAPL constituents.

### **Soil Sample Collection Methods**

Once the sample barrel or spoon was retrieved and opened, the soil cores were monitored by a photoionization detector (PID) and observed for the presence of contamination (see Appendix B for PID readings and observations). The surface layer of the core in contact with the sample barrel was cut away using a stainless steel knife at the appropriate depth to be sampled. EnCore™ samplers were pushed into the core

and the soil was immediately transferred into laboratory prepared preservation vials in accordance with EPA Method 5035. All VOC samples were collected and preserved for both high and low concentrations; therefore, allowing the analytical laboratory to determine the appropriate sample for data reporting. The remaining sample volumes needed for other analytical suites were then collected with a stainless steel spoon and placed directly into sample containers without compositing. Sampling information was documented on soil sample collection forms (see Appendix A).

## **2.5 Monitoring Wells**

Borehole/monitoring well locations were chosen based on areas of potential releases and the presumed groundwater gradient beneath the site; however, the boreholes were not used for water monitoring because the boreholes were installed with a bentonite mud rotary technique and not air rotary. Therefore, monitoring wells were installed within 10 feet of each borehole location once soil and bedrock sampling was complete. Monitoring well locations are shown in Figure 2-2 and Plate 1. A summary of well constructions is presented in Table 2-3. Detailed diagrams of construction and associated Texas well registration reports are presented as Appendix C.

### **2.5.1 Well Installation**

At the three shallow borehole locations, two-inch diameter polyvinyl chloride (PVC) monitoring wells were installed adjacent to the abandoned boreholes. Monitoring wells were installed with 4¼-inch interior diameter (ID) HSAs. Fifteen (15) feet of well screen was placed in each well and screens were placed across the water table within the unconfined Seymour Aquifer.

Prior to installation of the deep monitoring well (MW09), the pilot borehole was reamed with a Driltech D40K airlift drill rig using a 70-inch tricone bit. A 4-inch-diameter PVC well casing was installed with twenty five (25) feet of well screen placed at the bottom of the reamed hole. Stainless steel centralizers were placed every 20 feet along the well casing.

**Table 2-3**  
**Monitoring Well Construction Summary**

| <b>Well Construction</b>  | <b>MW06</b>                        | <b>MW07</b>                        | <b>MW08</b>                        | <b>MW09</b>                        |
|---|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| <b>Steel Isolation Casing Depth (ft, bgs)</b>                               | NI                                 | NI                                 | NI                                 | 91.0                               |
| <b>Well Casing/Screen Material</b>  | 2 inch diameter<br>schedule 40 PVC | 2 inch diameter<br>schedule 40 PVC | 2 inch diameter<br>schedule 40 PVC | 4 inch diameter<br>schedule 80 PVC |
| <b>Bottom of Well (ft, bgs)</b>   | 31.5                               | 23.5                               | 25.5                               | 211.5                              |
| <b>Screen Length (ft)</b>   | 15                                 | 15                                 | 15                                 | 25                                 |
| <b>Screen Interval Depths (ft, bgs)</b>                                     | 16 - 31                            | 8 - 23                             | 10 - 25                            | 186 - 211                          |
| <b>Stabilizers (stainless steel)</b>  | NI                                 | NI                                 | NI                                 | Every 20' from top of<br>screen    |
| <b>Filter Pack</b>  | 20-40 gradation<br>silica sand     | 20-40 gradation<br>silica sand     | 20-40 gradation<br>silica sand     | 20-40 gradation silica<br>sand     |
| <b>Seal Type (thickness)</b>  | Bentonite pellets (3')             | Bentonite pellets (3')             | Bentonite pellets (3')             | Bentonite slurry (36')             |
| <b>Water Level encountered during drilling (ft, bgs)</b>                    | 21.5                               | 11.3                               | 15.0                               | Approx. 20                         |
| <b>Static Water Level Measured in Well (ft, bgs)<br/>after Installation</b> | 21.68                              | 11.83                              | 20.30                              | NR                                 |
| <b>Top of Casing Elevation (ft, msl)</b>                                    | 1367.73                            | 1370.88                            | 1365.94                            | 1366.22                            |
| <b>Static Water Level Measured in Well (ft, btoc) on<br/>8/14/00</b>        | 24.37                              | 15.07                              | 23.65                              | 42.46                              |
| <b>Static Water Level Measured in Well (ft, msl) on<br/>8/14/00</b>         | 1343.36                            | 1355.81                            | 1342.29                            | 1323.76                            |

Notes:

NI - not installed

bgs - below ground surface

btoc - below top of casing



### **2.5.2 Well Development**

All installed wells were developed in order to restore the aquifers hydraulic conductivity and remove any fluids, cuttings and mobile particulates introduced during well drilling and installation. Monitoring well development logs are presented as Appendix D.

Well development of shallow monitoring wells (MW06-MW08) was accomplished using a surge block and submersible pump. Turbidity, specific conductance, temperature and pH were monitored during development. All parameters stabilized at each well, but turbidity could not be lowered below 990 nephelometric turbidity units (NTU) during development. A minimum of 11 casing volumes were removed at each well (see Appendix D). The deep monitoring well, MW09, was developed with a surge block and weighted bottom discharge bailer (sand bailer). The well was bailed dry twice during development. A total of 240 gallons was removed during development.

### **2.5.3 Groundwater Sampling**

Groundwater sampling using the low-flow (minimal drawdown) purging and sampling technique (Environmental Protection Agency (EPA), 1996) was attempted at each monitoring well. This technique has the advantage of producing samples which are more representative of aquifer conditions since the technique produces:

1. less entrainment of sediment and colloids normally not carried by groundwater flow
2. less mixing of stagnant casing water and formation water
3. minimal loss of VOCs, and
4. greater sample consistency

Low-flow sampling was successful at MW06 and MW07, but could not be achieved at MW08 and MW09. These later wells were therefore sampled with disposable teflon bailers with VOC tips. Monitoring well sample collection logs are presented in Appendix A.2.

## **Sampling Procedures**

Low-flow ground water sampling was performed using a Grundfos Redi-Flo2 submersible pump with teflon tubing. The pump intake was set within the lower portion of the screen interval of each well. Pumping rates during purging and sampling were kept below 0.5 L/min by adjusting the voltage regulator. Flow rates were measured every five minutes using a graduated cylinder.

Ground water quality parameters were also measured every five minutes during pumping, by use of a flow-through cell and a Horiba U-22 water quality meter. Water quality field parameters used to indicate stabilization included temperature, pH, specific conductivity, turbidity, dissolved oxygen and total dissolved solids (TDS). Based on EPA's low-flow ground water sampling procedures (EPA, 1996) stabilization was demonstrated with three successive field readings of temperature within 0.5 degrees Celsius, pH within 0.1, specific conductivity within 3 percent, and turbidity and dissolved oxygen within 10 percent. After water quality field parameters had stabilized, sample bottles were filled while maintaining the low flow pumping rate.

The pump and tubing were decontaminated prior to reuse in each well in accordance with Section 2.6 below; except MW09 required new tubing because of well depth.

At MW08, low flow pumping rates could not be sustained, apparently due to insufficient water head in the well. In accordance with the ESI WP (MK, 2000b), the pump was then lowered to the bottom of the well, and the well was pumped dry. The next day, after water level in the well had recovered, groundwater was sampled with a disposable teflon bailer. Due to high turbidity of bailed water (660 NTU), water for metal analysis was filtered through a 10-micron filter.

At MW09, groundwater could not be pumped to the surface with the Grundfos Redi-flo2 without consistently tripping the voltage regulator. Groundwater was therefore sampled with a disposable teflon bailer, after the groundwater level had recovered from development. The bailer was lowered to 200 feet bgs in order to collect water from the screened interval of the well.

#### **2.5.4 Water Level Measurements**

In order to construct a site specific potentiometric map for the site, water levels in all wells were measured on August 14, 2000, approximately 1 to 2 weeks following sampling. Water levels are listed in Table 2-3.

#### **2.6 Equipment Decontamination**

Drill rigs and drilling equipment such as augers, drill rods and bits, were decontaminated between boreholes and monitoring wells. Decontamination was performed at an on-site temporary decontamination pad using a high-pressure steam washer. Downhole sampling equipment (sample barrels, split spoons, and downhole submersible pump) and surface soil sampling tools were decontaminated at each sampling location between each sampling event or use. Decontamination procedures consisted of:

1. Wash and scrub with a solution of potable water and Alconox
2. Rinse with deionized (DI) water
3. Rinse with Reagent Grade II water

Equipment blank (EB) samples were collected by pouring Reagent Grade II water over deconned downhole and surface soil sampling equipment directly into sample containers.

#### **2.7 Investigative Derived Wastes (IDW)**

Excess soils, decontamination fluids, development and purge waters were containerized onsite during ESI field activities. Approximately 25 cubic yards of soils were generated during borehole and monitoring well installation and were placed in two lined roll-off bins. Approximately 8,800 gallons of fluids and waters were generated with the majority coming from the drilling, reaming and development of MW09. These fluids and waters were placed in three lined roll-off bins.

Composite waste samples were collected from the roll-off bins and analyzed for Toxicity Characteristic Leaching Procedure (TCLP) VOCs, SVOCs, pesticides, herbicides and metals. Samples were also analyzed for RCRA hazardous characteristics of ignitability, corrosivity and reactivity. Results of analyses are presented in Appendix H.4. No TCLP analytes were detected in the waste samples; therefore, the wastes were characterized as RCRA non-hazardous.

Waste soils and water were removed from the site by January Environmental Services, Inc., Oklahoma City, Oklahoma. Soils were disposed of in the Waste Management Industrial Landfill, Oklahoma City, Oklahoma and wastewaters were treated by January Environmental's onsite permitted industrial wastewater treatment facility. Disposal manifests are presented in Appendix F.2.

## **2.8 Location Survey**

Upon completion of ESI field activities, boreholes, monitor wells and surface soil sample locations were surveyed by a licensed surveyor in the state of Texas. Horizontal coordinates were recorded to the nearest 0.01 foot and established relative to the Texas State Plane coordinate system.

Ground surface elevations were measured at each borehole and soil sample locations to the nearest 0.1 foot. Top of well casing elevations were also measured on the casing's north side and recorded to the nearest 0.01 foot. Survey data are tabularized in Appendix G.

## **3.0 SITE GEOLOGY AND HYDROGEOLOGY**

---

### **3.1 Local Physiography, Geology and Underlying Aquifers**

This section describes the site-specific geology and hydrogeology based on information and data gathered during literature research and data obtained from lithologic logs and water level data acquired from borehole drilling and monitoring well installation.

Lithologic logs are presented as Appendix B and water level data is listed in Table 2-3.

The near surface stratigraphic units of concern for this study consist of Quaternary age surficial deposits and underlying Permian age redbeds (see Table 3-1). The local surficial deposits consist of a thin mantle of Recent age wind-blown sands and silts and the underlying Pleistocene age Seymour Formation (Willis and Knowles, 1953). The Seymour Formation is fluvial in origin and is comprised of fine to medium grained sands with interbedded silts and clays. The lower sands in the formation generally contains well rounded pebbles of chert, quartz and igneous rocks and may contain lenses of gravel (Price, 1979). Previous investigations at AMS No. 7 report a thickness for surficial deposits ranging from 42 to 80 feet beneath the site. The Seymour Formation rests on an erosional surface developed on the underlying Permian age bedrock. Relief of 135 feet occurs on this surface regionally beneath the Odell Sand Hills (Willis and Knowles, 1953).

The Seymour Formation is the major groundwater aquifer in Wilbarger County. The aquifer is unconfined (i.e., under water-table conditions). The quality of water ranges from fresh to slightly saline and well yields range from 30 to 400 gallons per minute (gpm) (Price, 1979). Thirty-two (32) wells are registered with the state of Texas in a three mile radius of AMS No. 7. All wells produce from the Seymour aquifer. Based on water-table elevation maps from 1951 through 1971 for the Odell Sand Hills (Price 1979), groundwater flow directions in the vicinity of the site may vary from slightly east of north to eastward.

The redbeds beneath the Seymour Formation belong to the Permian age San Angelos Formation of the Peace River Group (Table 3-1). The San Angelos Formation consists of red medium-grained deltaic sandstone (near the top of the formation) underlain by

**Table 3-1 Stratigraphy in the Vicinity of the Former AMS No. 7**

| <b>System</b> | <b>Series</b> | <b>Formation</b>    | <b>Maximum Thickness</b> | <b>Lithology</b>  | <b>Water-Bearing Characteristics</b>  |
|---------------|---------------|---------------------|--------------------------|---|---|
| Quaternary    | Recent        | Wind-blown deposits | Several feet             | Fine sands and clayey silts (loess)   | Predominantly above water table   |
|               | Pleistocene   | Seymour             | 112 feet                 | Contains white to red fine sands with interstratified lenses of silt and reddish-orange to gray clay. Caliche nodules in upper part. Lower portion of formation generally contains well rounded pebbles of chert, quartz and igneous rocks. Locally contains gravel lenses. Fluvial in origin. Buried erosional topography at base on top of underlying bedrock formations. | Yields mostly fresh to slightly saline water in small to moderate quantities. Main water supply for Wilbrager County. |
| Permian       | Guadalupe     | San Angelo          | 210 feet                 | Red to greenish-gray medium sandstone, deltaic in origin, near top of formation. Lower portion contains interbedded sandstone (as above) with cherty conglomerate, and red and green shale. Contains gypsum nodules and streaks of "satin spar" gypsum.   |   |

interbedded sandstone and shale (Price, 1979). The formation obtains a maximum thickness of 210 feet in Wilbarger County.

The San Angelos Formation is a minor aquifer in Wilbarger County. Water quality ranges from fresh to slightly saline and yields are generally less than 50 gpm. Hydraulic connection between the San Angelos Aquifer and the overlying Seymour aquifer is unknown.

## **3.2 Geology**

As mentioned above the local geology in the vicinity of AMS No. 7 consists of the unconsolidated fluvial Seymour Formation (Pleistocene age) which uniformly overlies the redbeds of the San Angelos Formation (Permian age). A generalized geologic cross-section across the site is shown in Figure 3-1. Location of the cross-section is shown on Figure 2-2.

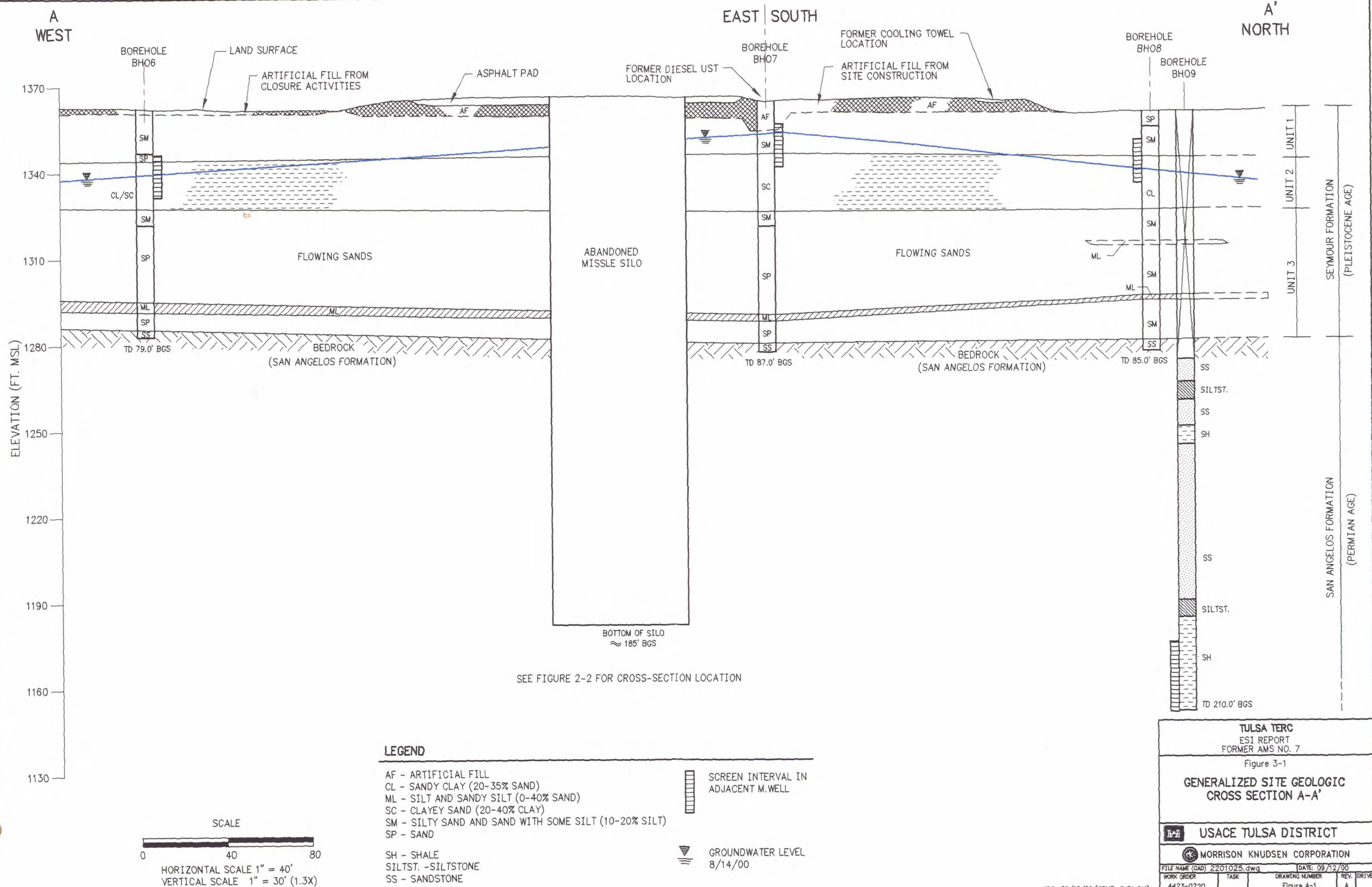
### **3.2.1 Seymour Formation**

The Seymour formation is divided into three informal units (for discussion purposes) based on lithology and thickness that are recognizable across the site. Unit 1 is an upper sandy unit, Unit 2 is a middle clayey unit and Unit 3 is a lower flowing sand unit. Each unit is discussed in the following text.

#### **Unit 1 (Upper Unit)**

Unit 1 consists of silty sands (SM) and clean sands (SP). The unit ranges from 14 to 18 feet in thickness. Sands of this unit are characteristically very fine grained and colors range from moderate reddish brown to pale orange. Lighter colors are probably due to the presence of caliche in the sand matrix. Sands also contain caliche nodules in areas. Silty sands have slit fractions estimated at 15 percent.

Artificial fill (AF) has been placed on top of this unit in some locations, thereby raising the local land surface. The majority of this AF was placed during silo construction and lesser amounts during silo closure (see Figure 3-1).





## **Unit 2 (Middle Unit)**

Unit 2 consists of sandy clay (CL) and clayey sand (SC). The unit ranges from 17 to 20 feet in thickness. Sandy clays (CL) exhibit low plasticity and have sand content ranging from 20 to 35 percent. Clay colors range from pale orange to light or yellowish brown. Clayey sands (SC) are characteristically very fine to fine-grained and contain clay content ranging from 20 to 40 percent. Colors are typically light or yellowish brown and pale olive. Scattered pebbles up to 1.5 inch in diameter occur in some of the clayey sands. Unit 2 contains small caliche nodules in areas.

## **Unit 3 (Lower Unit)**

Unit 3 consists predominantly of silty sands (SM) and clean sands (SP) with a few thin interbeds of silt (ML). The unit ranges from 42 to 46 feet in thickness. Silty and clean sands are characteristically very fine grained and colors are typically light brown. Silty sands contain silt fractions estimated at 10 to 20 percent. During auger drilling, flowing sand conditions were encountered throughout this unit. Adding mud to the HSAs was necessary to control the inflow of sand when sample barrels were removed. Sands of the lower Seymour Formation did not contain significant amounts of pebbles or any gravel lenses as reported in other studies (see Price, 1979).

One thin silt/sandy silt (ML) bed within Unit 3 appears to be traceable across the site. The bed ranges from 1 to 20 feet in thickness and was found from 8 to 14 feet above the base of the Seymour Formation (see Figure 3-1).

## **Basal Contact (Top of Bedrock)**

The base of the Seymour Formation is an erosional unconformity on top of the underlying San Angelos Formation. The contact encountered in the ESI boreholes was quite sharp and distinct consisting of light brown soft clean sand (SP) of Unit 3 overlying reddish brown hard sandstone of the San Angelos Formation. No gravel or slag were noticeable at the contact. Between the three shallow boreholes drilled at AMS No. 7, 8 feet of erosional relief exists on the basal contact.

### **3.2.2 San Angelos Formation**

Underlying the Seymour Formation are the red beds of the San Angelos Formation. The formation is Permian in age and constitutes the shallow bedrock beneath the site. The three shallow boreholes were drilled only several feet into the top of the formation

to verify the base of the overlying Seymour Formation. Borehole (BH09) was the only borehole drilled deeper to investigate the lithologies of the underlying San Angelos prior to placement of the deep monitoring well (MW09).

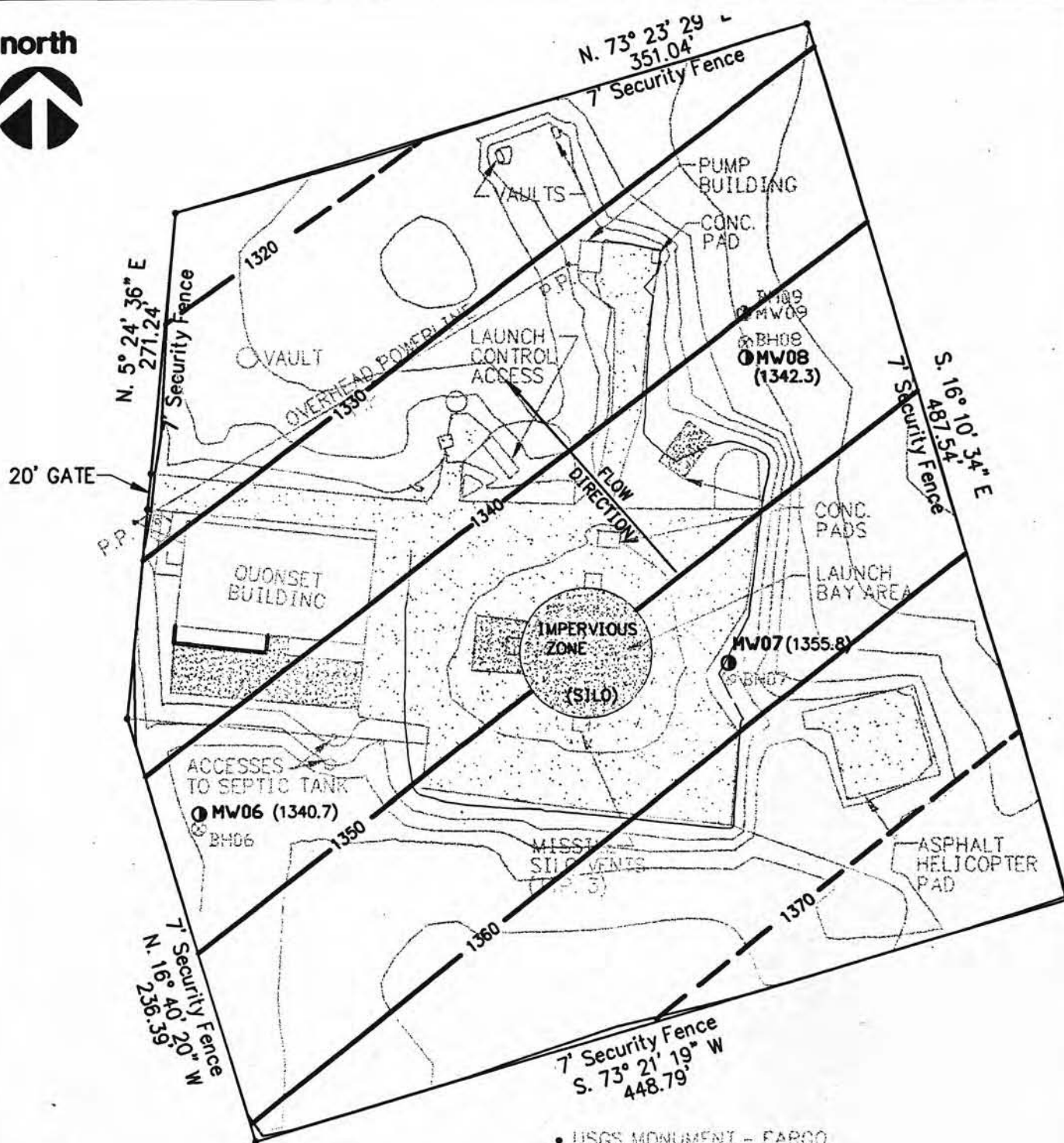
Approximately 130 feet of the San Angelos Formation was drilled at BH09. The San Angelos Formation in the borehole consists of an upper sandstone and a lower shale unit. The sandstone unit is approximately 91 feet in thickness and extends from the top of bedrock to about 172 feet bgs. The sandstone is characteristically very fine grained and quartzose in composition. Colors are pale to moderate reddish brown with pale olive mottling in zones. Low-angle cross bedding is noticeable throughout most of the section and flattened shale clasts are common. The sandstone is weakly to moderately cemented. Siltstone and sandy shale beds occur in the upper portion of the sandstone (see Figure 3-1).

The underlying shale unit consists predominantly of a very hard, dense non-fissile shale. The shale is moderate reddish brown in color with greenish gray occurring in spots and thin bands. Fractures in the shale are common and are distinguished by soft, wet zones separating the hard dense shale. The shale unit is separated from the overlying sandstone unit by a thin greenish gray siltstone unit. Approximately 38 feet of the shale was drilled at BH09. The base was not encountered.

### **3.3 Hydrogeology**

The Seymour Aquifer, which underlies the AMS No. 7, is the major groundwater aquifer for Wilbarger County. The aquifer is used locally for public and private water supply and irrigation. The aquifer is unconfined (i.e., under water-table conditions). Water levels in the shallow monitoring wells (MW06, MW07, and MW08) were measured on August 14<sup>th</sup>, 2000 and a site specific potentiometric map for the Seymour Aquifer was contoured. The regional groundwater flow direction is from slightly east of north to eastward (Price, 1979), but local groundwater flow beneath the site is to the northwest (see Figure 3.2). No hydraulic conductivity measurements for the Seymour Aquifer were gathered during this investigation.

north



## LEGEND

- ⊗ ESI SHALLOW BOREHOLE (AMS7- )
- ESI SHALLOW MONITORING WELL (AMS7- )  
SHOWING ELEVATION (ft, msl) OF POTENTIOMETRIC  
SURFACE WITHIN SEYMOUR AUIFER
- ⊗ ESI DEEP BOREHOLE/  
MONITORING WELL (AMS7- )

—1360— COUNTOUR INTERVAL (ft, msl)

CONCRETE

ASPHALT

NOTE: CONTOURED SURFACE ASSUMES  
PLANAR NATURE

TULSA TERC  
ESI REPORT  
FORMER AMS NO. 7

Figure 3-2

CONTOURED POTENTIOMETRIC SURFACE  
(WATER TABLE) WITHIN SEYMOUR  
AQUIFER (Aug. 14, 2000)



USACE TULSA DISTRICT



MORRISON KNUDSEN CORPORATION

FILE NAME (CAD) 2201023.dwg

DATE: 05/02/00

WORK ORDER

TASK

DRAWING NUMBER

REV. DATE

4423

0220

2201023

A

<CPD: 09/20/00 [TIME: 4:43 PM]>

The underlying San Angelos (bedrock) Formation is a minor aquifer in Wilbarger County. Within a three-mile radius of AMS No. 7, no wells are registered in this aquifer. The deep monitoring well MW09 was screened across a fractured shale within this aquifer. Since only one well penetrated the aquifer, the groundwater flow direction is unknown. On August 14, 2000, the water level in MW09 was approximately 20 feet below the water level in the overlying Seymour Aquifer (MW08). Since this water level measurement was taken only three days after development of this deep well, equilibrium may not yet have been achieved. Whether the San Angelos aquifer is under confined conditions or in connection with the overlying Seymour aquifer is currently unknown, and will require further water level measurements to determine.

## 4.0 REGULATORY COMPLIANCE

---

Closure and remediation must comply with TNRCC Chapter 335, Subchapter S, Risk Reduction Standards (RRS) for Industrial Solid Waste and Municipal Hazardous Waste sites. The requirements of TNRCC Chapter 335, Subchapter S will, when adequately carried out, assure adequate protection of human health and the environment from potential exposure to contaminants associated with releases from solid waste management facilities or other areas. Cleanup levels are specified in the regulation for different types of contaminated media such as groundwater and soil, and for cross-media contamination pathways such as soil to groundwater and soil to air. General procedures based on scientific principles are provided or referenced by the regulations so that specific numeric cleanup levels can be generated in accordance with the risk reduction standards.

Specific cleanup levels are developed after a property use can be designated as residential or non-residential (industrial). Non-residential property is any real property or portion of a property not currently being used for human habitation or for other purposes with a similar potential for human exposure, at which activities have been or are being conducted. Industrial is defined as any non-residential property

All facilities are subject to the residential soil requirements unless:

- the property is located within the jurisdictional area of a zoning authority and the property is zoned for commercial or industrial use,
- the property is not located within the jurisdictional area of a zoning authority and documentation is provided that the activities being conducted on the property satisfy the definition for non-residential property, or
- for government-owned (local, state or federal) property which does not satisfy either of the above conditions and does have non-residential activities occurring on all or portions of the property. Documentation may be provided that access will be restricted such that the exposure assumptions remain valid for the duration of government control.

Additionally, in accordance with TNRCC Subchapter 335.556, an analysis of the probable point of exposure is necessary to determine the location where human or environmental receptors can come into contact with contaminants.

### **Risk Reduction Standard 1 (RRS1)**

This standard requires closure/remediation to concentrations equivalent to background concentrations of the environment adjacent to the site. If the Practical Quantitation Limit (PQL) for chemical analysis is greater than background, then the PQL rather than background shall be used as the cleanup level.

To meet this standard the site is required to remove all hazardous waste and hazardous waste residues and contaminated design and operating system components such as liners, leachate collection systems and dikes. Associated contaminated media, such as soils and groundwater, must be removed or remediated to background or PQL levels.

### **Risk Reduction Standard 2 (RRS2)**

For closure of hazardous waste management units and response to unauthorized discharges of hazardous waste, all hazardous waste and hazardous waste residues must be removed from the unit or area of the unauthorized discharge. Contaminated design and operating system components such as liners, leachate collection systems and dikes must be removed from the unit or area of the unauthorized discharge. Phase-separated non-aqueous liquids released from the unit that is undergoing closure or remediation must be removed or decontaminated to the extent practicable. For remediation of media that have become contaminated by releases from a hazardous waste management unit or by other unauthorized discharge of hazardous waste, the contaminated media must be removed or decontaminated to RRS2 cleanup levels specified in TNRCC Chapter 335 or such other lower levels necessary to be in conformance with current hazardous waste regulations.

The concentration of a contaminant in contaminated media of concern such as groundwater or soil cannot exceed RRS2 cleanup levels as determined using the process in TNRCC Chapter 335. RRS2 cleanup levels for individual contaminants are established by Texas or federal promulgated health-based standards, or, when these are not available or do not provide appropriate protection for human health or the environment, the site must develop RRS2 cleanup levels based on procedures specified or referenced in TNRCC Chapter 335 for determining other numeric criteria, referred to

as Medium Specific Concentrations (MSCs). Necessary adjustments to these numeric criteria may also be required based on site exposure scenarios and pathways.

### **Risk Reduction Standard 3 (RRS3)**

If the site is unable to meet the requirements of RRS 1 or RRS 2 through closure or remediation, then it must meet the requirements of RRS 3.

This condition requires a remedial investigation report, which contains sufficient documentation such as, but not limited to, descriptions of procedures and conclusions of the investigation to characterize the nature, extent, direction, rate of movement, volume, composition and concentration of contaminants in environmental media of concern, including summaries of sampling methodology and analytical results. Information obtained from attempts to attain RRS 1 or RRS 2 may be submitted for this purpose.

## 5.0 INVESTIGATION RESULTS

---

This section summarizes and compares the analytical results to site closure criteria. Sample data are summarized in tabular form in Appendices H and I. Site closure criteria are presented in Appendix J.

AMS No. 7 is currently owned by the Northside Independent School District No. 905 (local government) of Vernon, Texas. The school district uses this facility for Future Farmers of America (FFA) exhibitions and livestock shows several times each year, whereby access is controlled by a gated fence. Therefore the project site is considered non-residential, and all data comparisons are based on TNRCC risk reduction standards and medium specific concentrations (MSCs) applicable to non-residential or industrial activities and Texas-Specific Background Concentrations (see Appendix J). MSC values presented in this report were taken from the July 14, 1999 TNRCC Updated Examples of Standard No.2, Appendix II Medium-Specific Concentrations, Subchapter S: Risk Reduction Standards (see Appendix J.1). The most recently published Texas-Specific Background Concentrations are reported in a TNRCC Interoffice Memorandum, dated June 28 (see Appendix J.2).

In accordance with TNRCC Subchapter 335.556, an analysis of probable point of exposure was completed that defines the point of exposure as the location where human or environmental receptors can come into contact with contaminants. The analysis determined the potential exposure pathways for AMS No. 7 are:

1. ground water ingestion,
2. soil inhalation, ingestion, and dermal contact, and
3. groundwater protection.

No surface water exists on site; therefore, surface water ingestion is not an exposure pathway.

For non-residential scenarios, the concentration of a contaminant in near-surface soils (i.e., within two feet of the land surface) shall not exceed the lower of the Non-Residential Soil MSC (SAI-Ind) based upon worker ingestion of soil and inhalation of particulates and volatiles, and the Non-Residential Soil-to-Ground Water Cross-Media Protection Concentration (GWP-Ind). The concentration of a contaminant in subsurface soils (i.e., greater than two feet in depth from the land surface) shall not exceed the GWP-Ind.



The analytical results for each surface soil, subsurface soil, and groundwater samples collected during this study are presented in Appendix H with associated lab and validation qualifiers. All soil samples were analyzed for VOCs, SVOCs, pesticides/herbicides, PCBs, TRPH, and heavy metals. Additionally, tentatively identified compounds (TICs) were also reported from the VOC and SVOC analyses. Groundwater samples were analyzed for the parameters listed in the TNRCC Drinking Water Standards, and TRPH. TNRCC Drinking Water Standards include VOCs, trihalomethanes (THMs), SVOCs, insecticides/herbicides, carbamate insecticides, organohalide pesticides, PCBs, endothall, glyphosate, diquate, metals, fluoride, cyanide, and nitrate/nitrite.

For target analytes not detected above the method detection limit (MDL), the sample MDL is shown. MDLs vary slightly from sample to sample based on moisture content and dilution factors. All TICs are reported as estimated concentration and MDLs are not determined for these compounds. A precision, accuracy, representativeness, completeness, comparability and sensitivity (PARCCS) summary for ESI data is presented in Appendix K and the complete lab reports and validation reports for samples are presented in Appendix L (both under a separate cover).

Results of sampling and analyses are discussed in the following sections by media sampled (surface soils, subsurface soils and groundwater).

## **5.1 Surface Soils**

A total of thirteen (13) surface soil samples were collected and analyzed. These consist of three off-site samples (SS05-07), seven on-site samples (SS08 - SS14) and the surface interval from three boreholes (BH06 - BH08) (see Plate 1 for locations) located onsite. All surface soil samples were collected from the upper 6 inches of soil. On-site samples were placed discretely at or near areas of potential releases based on known past site activities that include the incinerator, cooling towers, and underground diesel fuel storage tank.

Various VOCs and SVOCs were detected from both offsite and onsite surface soil samples. Notable contaminants found onsite that may be indicative of a contaminant release include:

- benzene, toluene, 1,2,4-trimethylbenzene, 1-3-5-trimethylbenzene and xylenes near the incinerator.

- trichlorethene (TCE), toluene, and xylenes near the cooling tower.
- benzene, toluene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene and xylenes near the UST.

However, all VOCs and SVOCs were reported below MSC for (1) inhalation, ingestion, and dermal contact; and (2) groundwater protection for industrial use (Appendix J.1).

Low levels of PCBs were detected from onsite samples near the incinerator, cooling tower, and USTs and not from offsite samples; therefore this may be indicative of a contaminant release. The concentrations do not exceed the MSC for inhalation, ingestion, and dermal contact; but, do exceed the MSC for groundwater protection. However, subsurface PCBs concentrations reported in Section 5.2 below were not detected; therefore, groundwater protection criteria is met.

No pesticides, herbicides or TRPH were detected in the surface soil samples.

Bis(2-ethylhexyl)phthalate detected in most of the soil samples in the previous SI (see Table 1-1) was not detected in surface or subsurface soils during this investigation. The MDL for bis(2-ethylhexyl)phthalate during this ESI was approximately four times lower than the SI (70 µg/kg versus 330 µg/kg). Therefore the absence of detectable levels of this compound at a lower MDL suggests that the presence of this SVOC in SI samples was an artifact of sampling or lab procedures and not an onsite contaminant.

Lead and zinc were the notable metals reported for surface soil samples at the incinerator, cooling tower, and USTs that also exceeded background metal concentrations reported from offsite samples. Additionally, all metals were found less than TNRCC established background levels, with the exception of low levels of lead and zinc noted near the incinerator, cooling tower, and USTs. The Texas-specific background concentration for lead and zinc is 15 mg/kg and 30 mg/kg respectively, as reported in a TNRCC Interoffice Memorandum, dated June 28, 2000 (see Appendix J.2).

Lead concentrations reported in onsite surface soils were:

- incinerator : 152 mg/kg, 19.3 mg/kg, and 10.4 mg/kg
- cooling tower: 18.4 mg/kg and 6.6 mg/kg,
- USTs: 22.2 mg/kg and 14.5 mg/kg

Zinc concentrations reported in onsite surface soils were:

- Incinerator: 102 mg/kg, 45.6 mg/kg, and 18.8 mg/kg
- Cooling tower: 181 mg/kg and 32.2 mg/kg
- USTs: 44.3 mg/kg and 11 mg/kg

## **5.2 Subsurface Soils**

A total of twelve (12) subsurface soil samples from three boreholes were collected and analyzed. Samples were collected at 5-foot intervals within the vadose zone at each borehole and directly above the underlying alluvial/bedrock contact. Sample depth intervals for each subsurface sample are shown in Table 2-1.

Borehole BH06 was drilled along the southwestern boundary of the site in an area believed to be unaffected by site activities. Borehole BH07 was placed at the former location of the on-site diesel UST. Borehole BH-08 was placed north of former cooling tower and south of the incinerator (see Plate 1).

### **Borehole BH06**

Subsurface soil samples were collected at depths of 5, 10, 18 and 76 feet bgs at borehole BH06. No organic compounds were detected in subsurface soils at this borehole, except methylene chloride and acetone contaminants were detected near background concentrations; refer to SS05, SS06, and SS07. All metal concentrations were less than the Texas-specific background concentrations (Appendix J.2).

### **Borehole BH07**

Subsurface soil samples were collected at depths of 5, 10, and 85 feet bgs at borehole BH07. Four VOCs (toluene, 1,2,4-trimethylbenzene, xylenes and pentane) were detected in the 5-foot depth sample at low concentrations less than MSC values for inhalation, ingestion, dermal contact, and groundwater protection (Appendix J.1). No VOCs were detected in the underlying 10-foot depth sample directly above groundwater except methylene chloride was detected near background concentrations, refer to SS05, SS06, and SS07; therefore, VOC contamination appears to be confined to the surface and near surface at this former UST location. One SVOC, 1,1,2,2-tetrachloroethane, was detected at the 10-foot depth sample at a concentration below the MSC values for inhalation, ingestion, dermal contact, and groundwater protection (Appendix J.1).

No pesticides/herbicides, PCBs, or TRPH were detected in the subsurface at borehole BH07.

As discussed earlier, a liquid drilling additive (Insta-Vis) was added to borehole BH07 at about a depth of 65 feet bgs. Insta-Vis is a liquid polymer consisting of a surfactant dispersed in a mineral oil base. The additive was added by the drillers in attempts to remove sand and fines from the augers and stabilize the borehole walls. This additive was noticeable in the 85-foot depth interval sample; therefore no sample was collected because of the petroleum contaminants introduced from the Insta-Vis.

All metal concentrations were less than the Texas-specific background concentrations (Appendix J.2).

### **Borehole BH08**

Subsurface soil samples were collected at depth of 5, 10, 15, 18 and 80 feet bgs at borehole BH08.

No organic compounds were detected in soils at the 5-, 10-, and 15-foot depth intervals, although from 5 to 15 feet bgs there was a slight oil odor and field PID readings were greater than 2000 units. No visible staining or discoloration was noticeable. Noticeable odor and high PID readings, with a lack of soil discoloration and detected compounds suggests the occurrence of contamination in a soil gas phase rather than adhered to the soil matrix.

One notable organic contaminant, trichloroethene (TCE), was detected at a concentration of 36.7 µg/kg in the 18-foot depth sample, below this soil gas zone. PID readings at this depth were 50 units. Though this TCE value is below the MSC concentration for ground water protection, its presence indicates a possible contaminant release. No organic compounds were detected in the underlying sample (S-80) collected at the alluvial/bedrock contact.

All metal concentrations were less than the Texas-specific background concentrations (Appendix J.2).

## **5.3 Groundwater**

Four groundwater samples were collected and analyzed. These consist of three samples from the Seymour Aquifer (MW06, 07, 08) and one from the underlying San

Angelos Aquifer (MW09). After well installation and prior to development of each well, a disposable bailer was lowered into the well across the water table to check for any free-phase product. No product or sheen was found in any of the wells.

### **Monitoring Well MW06**

Monitoring Well MW06 was placed in an area believed to be unaffected by DOD activities as a background well. As noted above, no organic compounds were detected in soil samples collected at this location and no organic compounds were detected in the groundwater at this location. All metals and other inorganic contaminants met TNRCC drinking water standards (Appendix J.1).

### **Monitoring Well MW07**

Monitoring Well MW07 was placed at the former diesel UST location. One SVOC TIC, designated as hydrocarbon oil, was detected in groundwater at this location with an estimated concentration of 21 µg/l; however, no oily sheens were observed. No other organic compounds were detected. All metals and other inorganic contaminants met TNRCC drinking water standards (Appendix J.1).

### **Monitoring Well MW08**

Monitoring well MW08 was placed near the former cooling tower location. Low concentrations of VOCs and SVOCs were detected below MSC groundwater values; the only exception was a TCE concentration of 140 µg/l, which exceeded the groundwater standard of 5 µg/l (Appendix J.1).

As discussed earlier, TCE was detected in subsurface soils from the adjacent borehole BH08 and the other VOCs detected — 1,1-dichloroethylene, cis-1,2-dichloroethylene and trans-1,2-dichloroethylene — are known biodegradation products of TCE, which are all indicators of a contaminant release.

All metals and other inorganic contaminants met TNRCC drinking water standards (Appendix J.1).

### **Monitoring Well MW09**

Monitoring Well MW09 was screened across a fractured shale of the San Angelos aquifer to investigate any potential releases from the base of the on-site silo.

Bis(2-ethylhexyl)phthalate was the only organic compound detected at MW09; however, the concentration was below TNRCC drinking water standards. All metals and other inorganic contaminants also met TNRCC drinking water standards (Appendix J.1).

#### **5.4 Preliminary Comparison of ESI Data to RRS1 and RRS2 Cleanup Levels**

A preliminary comparison of contaminant concentrations in soils and groundwater is made to RRS1 and RRS2 cleanup levels. A summary of the comparison is shown in Table 5-1 and a summary of detects is presented in Appendix I.

RRS1 cleanup levels for organics are established as the average MDL achieved by the laboratories. It should be noted that sample MDLs vary depending upon soil moisture content and dilution factors (required for analysis). TICs reported in the VOC and SVOC analyses are estimated concentrations and do not have established MDLs by the laboratories, therefore RRS1 cleanup levels are not determined for these compounds. RRS1 cleanup levels for metals are statistically determined background values and have not been performed in this study. Table 5-1 merely lists the laboratory MDL for metals.

RRS2 cleanup levels (MSCs) are for an industrial scenario and values shown in Table 5-1 are those calculated by TNRCC and contained in Appendix II of TNRCC Chapter 335. Maximum concentrations of compounds and metal reported for ESI sampling are shown in Table 5-1 for comparison.

Direct comparisons of the ESI organic and metals data to RRS1 and RRS2 cleanup levels are discussed below. The TNRCC risk reduction standard guidance allows for direct comparison of the results of analysis of discrete samples of the medium of concern with the cleanup level.

Table 5-1

**Summary of Contaminant Maximum Concentrations and Known Clean Up Levels  
for RRS1 and RRS2 (Industrial Scenario)  
AMS No. 7**

| Matrix/<br>Analytical Suite/ Analyte   | CAS No.    | ESI<br>Maximum<br>Concentrati<br>on |        | RRS2 MSCs |           |            |
|--|------------|-------------------------------------|--------|-----------|-----------|------------|
|  |            | RRS1<br>(Avg. MDL)                  | GW-Ind | GWP-Ind   | SAI-Ind   |            |
| SOILS                                  |            |                                     |        |           |           |            |
| VOCs (ug/kg)                           |            |                                     |        |           |           |            |
| Acetone                                | 67-64-1    | 190                                 | 7.59   | NA        | 1,020,000 | 4,160,000  |
| Benzene                                | 71-43-2    | 2.42                                | 0.67   | NA        | 500       | 162,000    |
| 2-Butanone (MEK)                       | 78-93-3    | 9.14J                               | 2.81   | NA        | 511,000   | 14,000,000 |
| Carbon disulfide                       | 75-15-0    | 3.37                                | 0.78   | NA        | 1,020,000 | 23,400     |
| Methylene chloride                     | 75-09-2    | 44.0                                | 5.35   | NA        | 500       | 13,800     |
| Toluene                                | 108-88-3   | 10.8                                | 0.72   | NA        | 100,000   | 3,630,000  |
| Trichloroethene (TCE)                  | 79-01-6    | 36.7                                | 0.64   | NA        | 500       | 2,850      |
| 1,2,4-Trimethylbenzene                 | 120-82-1   | 5.37                                | 1.26   | NA        | ---       | ---        |
| 1,3,5-Trimethylbenzene                 | 108-67-8   | 2.74                                | 0.89   | NA        | ---       | ---        |
| Xylene (total)                         | 1330-20-7  | 17.8                                | 1.39   | NA        | 1,000,000 | 5,800,000  |
| VOC tics (ug/kg)                       |            |                                     |        |           |           |            |
| Acetaldehyde                           | 75-07-0    | 5J                                  | ND     | NA        | ---       | ---        |
| Acetic acid, methyl ester              | 79-20-9    | 56J                                 | ND     | NA        | ---       | ---        |
| Arsenous acid,<br>tris(trimethylsilyl) | NF         | 3J                                  | ND     | NA        | ---       | ---        |
| Benzaldehyde                           | 100-52-7   | 7J                                  | ND     | NA        | ---       | ---        |
| Butanal                                | 123-72-8   | 10J                                 | ND     | NA        | ---       | ---        |
| Butanal, 3-methyl-                     | 590-86-3   | 5J                                  | ND     | NA        | ---       | ---        |
| Butane, 2-methyl-                      | 78-78-4    | 35J                                 | ND     | NA        | ---       | ---        |
| Cyclohexane                            | 110-82-7   | 10J                                 | ND     | NA        | ---       | ---        |
| Cyclohexane, methyl-                   | 108-87-2   | 14J                                 | ND     | NA        | ---       | ---        |
| Cyclotetrasiloxane,<br>octamethyl      | 556-67-2   | 11J                                 | ND     | NA        | ---       | ---        |
| Cyclotrisiloxane, hexamethyl           | 541-05-9   | 4J                                  | ND     | NA        | ---       | ---        |
| 2-Furancarboxaldehyde                  | 98-01-1    | 28J                                 | ND     | NA        | ---       | ---        |
| Heptanal                               | 111-71-7   | 3J                                  | ND     | NA        | ---       | ---        |
| Hexanal                                | 66-25-1    | 190J                                | ND     | NA        | ---       | ---        |
| Hexane                                 | 110-54-3   | 23J                                 | ND     | NA        | ---       | ---        |
| Pentanal                               | 110-62-3   | 42J                                 | ND     | NA        | ---       | ---        |
| Pentane                                | 109-66-0   | 59J                                 | ND     | NA        | ---       | ---        |
| Pentane, 2-methyl-                     | 107-83-5   | 19J                                 | ND     | NA        | ---       | ---        |
| SVOCs (ug/kg)                          |            |                                     |        |           |           |            |
| Benzo(a)anthracene                     | 56-55-3    | 145J                                | 50     | NA        | ---       | ---        |
| Benzo(a)pyrene                         | 50-32-8    | 76J                                 | 60     | NA        | ---       | ---        |
| Benzo(b)fluoranthene                   | 205-99-2   | 126J                                | 50     | NA        | ---       | ---        |
| Chrysene                               | 218-01-9   | 142J                                | 50     | NA        | ---       | ---        |
| Fluoranthene                           | 206-44-0   | 426                                 | 60     | NA        | 409,000   | 81,800,000 |
| Phenanthrene                           | 85-01-8    | 191J                                | 60     | NA        | ---       | ---        |
| Pyrene                                 | 129-00-0   | 329J                                | 50     | NA        | 310,000   | 61,000,000 |
| SVOCs tics (ug/kg)                     |            |                                     |        |           |           |            |
| 1,1,2,2-Tetrachloroethane              | 79-34-5    | 15J                                 | ND     | NA        | 1,430     | 11,700     |
| PCBs (ug/kg)                           |            |                                     |        |           |           |            |
| Aroclor 1260                           | 11096-82-5 | 166                                 | 3.6    | NA        | 50        | 10,000     |

Table 5-1 (cont.)

**Summary of Contaminant Maximum Concentrations and Known Clean Up Levels  
for RRS1 and RRS2 (Industrial Scenario)  
AMS No. 7**

| Matrix/<br>Analytical Suite/ Analyte | CAS No.    | ESI<br>Maximum<br>Concentrati<br>on | RRS1<br>(Avg. MDL) | RRS2 MSCs |         |         |
|--------------------------------------|------------|-------------------------------------|--------------------|-----------|---------|---------|
|                                      |            |                                     |                    | GW-Ind    | GWP-Ind | SAI-Ind |
| Metals (mg/kg)                       |            |                                     |                    |           |         |         |
| Aluminum                             | 7429-90-5  | 15,900                              | 2.06               | NA        | ---     | ---     |
| Arsenic                              | 7440-38-2  | 2.9                                 | 0.67               | NA        | 5       | 3.27    |
| Barium                               | 7440-39-3  | 131                                 | 0.05               | NA        | 200     | 137,000 |
| Calcium                              | 7440-70-2  | 53,600                              | 1.14               | NA        | ---     | ---     |
| Chromium                             | 7440-47-3  | 17.9 (9/25)                         | 0.22               | NA        | 10      | 5,110   |
| Copper                               | 7440-50-8  | 16                                  | 0.21               | NA        | ---     | ---     |
| Iron                                 | 7439-89-6  | 16,000                              | 1.13               | NA        | ---     | ---     |
| Lead                                 | 7439-92-1  | 152 (25/25)                         | 0.48               | NA        | 1.5     | 1,000   |
| Magnesium                            | 7439-95-4  | 8,250                               | 1.11               | NA        | ---     | ---     |
| Manganese                            | 7439-96-5  | 342                                 | 0.04               | NA        | ---     | ---     |
| Nickel                               | 7440-02-0  | 13.1 (2/25)                         | 0.32               | NA        | 10      | 20,400  |
| Potassium                            | 7440-09-7  | 4,370                               | 5.93               | NA        | ---     | ---     |
| Sodium                               | 7440-23-5  | 123                                 | 11.3               | NA        | ---     | ---     |
| Vanadium                             | 7440-62-2  | 22.2                                | 0.18               | NA        | ---     | ---     |
| Zinc                                 | 7440-66-6  | 181                                 | 0.21               | NA        | ---     | ---     |
| Groundwater                          |            |                                     |                    |           |         |         |
| VOCs (ug/l)                          |            |                                     |                    |           |         |         |
| 1,1-Dichloroethylene                 | 75-35-4    | 0.3                                 | 0.2                | 7         | NA      | NA      |
| cis-1,2-Dichloroethylene             | 156-59-2   | 30                                  | 0.1                | 70        | NA      | NA      |
| trans-1,2-Dichloroethylene           | 156-60-5   | 2.8                                 | 0.1                | 100       | NA      | NA      |
| VOC tics (ug/l)                      |            |                                     |                    |           |         |         |
| Acetone                              | 67-64-1    | 8.7                                 | ND                 | 10,220    | NA      | NA      |
| Chloroform                           | 67-66-3    | 0.5                                 | ND                 | 336       | NA      | NA      |
| 4-Isopropyltoluene                   | 99-87-6    | 0.1                                 | ND                 | ---       | NA      | NA      |
| SVOCs (ug/l)                         |            |                                     |                    |           |         |         |
| Bis(2-ethylhexl)phthalate            | 117-81-7   | 1.3J                                | 0.6                | 20.4      | NA      | NA      |
| SVOC tics (ug/l)                     |            |                                     |                    |           |         |         |
| Camphorsulfonic Acid                 | NF         | 3.8J                                | ND                 | ---       | NA      | NA      |
| Tetradecanoic acid                   | 544-63-8   | 17J                                 | ND                 | ---       | NA      | NA      |
| Metals (ug/l)                        |            |                                     |                    |           |         |         |
| Antimony                             | 7440-36-0  | 1.0                                 | 0.2                | 6.0       | NA      | NA      |
| Barium                               | 7440-39-3  | 410                                 | 0.2                | 2000      | NA      | NA      |
| Chromium                             | 7440-47-3  | 15                                  | 0.2                | 100       | NA      | NA      |
| Copper                               | 7440-50-8  | 10                                  | 0.5                | 1,300     | NA      | NA      |
| Lead                                 | 7439-92-1  | 14                                  | 0.5                | 15        | NA      | NA      |
| Nickel                               | 7440-02-0  | 100                                 | 0.5                | 100       | NA      | NA      |
| Inorganics mg/l                      |            |                                     |                    |           |         |         |
| Flouride                             | 7782-41-4  | 0.9                                 | 0.1                | 4.0       | NA      | NA      |
| Nitrate                              | 14797-65-0 | 9.5 (1/4)                           | 0.5                | 1.0       | NA      | NA      |
| Nitrite                              | 14797-55-8 | 0.01                                | 0.01               | 10        | NA      | NA      |

Notes:

NA - Not Applicable, ND - Not Determined, NF - Not Found

--- MSC not calculated

Concentrations exceeding a MSC are highlighted with the exceedance frequency shown in parenthesis.



#### **5.4.1 Comparison to RRS1**

If closure to RRS1 is achieved, no deed recordation or post-closure care would be required for the site, upon approval from the state executive director. However, based on existing ESI data, AMS No.7 cannot be closed to RRS1 by a direct comparison method without remediation of soils and groundwater. Direct comparison of site concentrations to MDLs for organics more than likely will not allow closure for all compounds without remediation. To achieve closure (with or without remediation) to RRS1, MDLs or practical quantitation limits (PQLs) for VOC and SVOC TICs may be required.

#### **5.4.2 Comparison to RRS2**

For organic compounds with calculated RRS2 MSCs (see Table 5-1), current known concentrations in on-site soils and groundwaters are below the MSCs except for TCE in MW08. TCE exceeds the groundwater MSC for industrial use and must be confirmed through additional sampling. For metals with calculated MSCs, three have on-site concentrations in soils above the associated MSCs. Chromium concentrations are above the MSC in 9 out of 25 soil samples. Lead concentrations are above the MSC in all 25 soil samples. Nickel concentrations are above the MSC in 2 out of 25 soil samples. This high frequency of MSC exceedance is probably due to natural metal content in the soils rather than on-site DOD activities. Additionally, zinc and lead surface soil samples were found to exceed the Texas-specific background concentrations shown in Appendix J.2, 50 percent and 40 percent, respectively. Therefore, additional testing may be required to establish background to avoid surface soil removal.

If RRS2 is achieved, with or without remediation, deed recordation is required but post-closure care is not, upon approval of the state executive director.

If the site cannot meet RRS1 or RRS2 closure requirements, it must comply with the process required for RRS3. This process involves developing a remedial investigation report, a baseline risk assessment report; and performing a corrective measure study, deed recordation, and post closure care requirements as specified in TNRCC Chapter 335.

## **6.0 SUMMARY**

---

This section summarizes the results and findings of the ESI field investigation and regulatory compliance review. It should be understood that AMS 7 operations ceased more than 30 years ago; therefore, natural attenuation of biodegradable products should be expected if aerobic soil and groundwater conditions prevail.

### **6.1 Geology/Hydrogeology**

The site geology consists of approximately 80 feet of unconsolidated alluvium of the Pleistocene age Seymour Formation which overly sandstone and shale (bedrock) of the Permian age San Angelos Formation. Alluvium consists of three informal units recognized across the site which include an upper sand unit (14 to 18 feet thick), a middle clayey unit (17 to 20 feet thick) and a lower sand unit (42 to 46 feet thick). The contact with the underlying bedrock is sharp and distinct. The underlying bedrock consists of an upper sandstone unit (91 feet thick) underlain by a dense but fractured shale (38+ feet thick).

The groundwater flow in the Seymour Aquifer, beneath the site, is to the northwest based on three monitoring wells screened across the water table within the aquifer. On a regional basis, flow is slightly east of north to eastward (Price, 1979). Since only one monitoring well was screened in the underlying San Angelos Formation, the groundwater flow direction in that aquifer is unknown. No hydraulic connection between the two aquifers is currently known; however, it appears the missile silo could have penetrated both aquifers during construction, as noted in Figure 3-1.

### **6.2 Field Sampling Program**

Thirteen surface soil samples and 12 subsurface soil samples from three boreholes were collected and analyzed. Three shallow wells and one deep well were installed, sampled, and analyzed. ESI soil samples were analyzed for VOCs, SVOCs, pesticides/herbicides, PCBs, TRPH, and total metals as listed in 40 CFR, Part 264, Appendix IX. This list of parameters was more comprehensive than used during the 1995 SI; specifically, this list included pesticides/PCBs, herbicides, and 21 additional metals. ESI groundwater samples were analyzed for parameters identified in the TNRCC drinking water standards. Also, tentatively identified compounds were reported in addition to target analytes in the VOC and SVOC range. ESI analyses were also performed at MDLs significantly lower than the previous SI.

### 6.3 Nature and Extent of Contamination

Based on direct comparison of existing data, AMS No. 7 cannot be closed in accordance with RRS1 or RRS2 cleanup levels without remediation of soils and groundwater.

Surface soil sampling around the incinerator and cooling towers detected VOCs, SVOCs, and PCB concentrations above offsite surface soil conditions. Though these concentrations are very low, the contaminant concentrations are above background levels; therefore, removal and disposal is necessary to achieve RRS 1 cleanup standards. Existing VOCs, SVOCs, and PCBs are below MSC industrial exposures for inhalation, ingestion, and dermal contact and may satisfy RRS2 cleanup levels; however, lead and zinc were found above Texas-Specific Background Concentrations and must be removed to achieve RRS1 and RRS2 cleanup levels. The horizontal extent of contamination has not been thoroughly defined with this study; therefore, site cleanup measures should utilize site process knowledge combined with field screening measures during surface soil removal to identify the horizontal perimeter of contaminant removal.

VOCs and SVOCs were detected below RRS2 cleanup levels in all subsurface soil samples from the three boreholes. However, petroleum vapors and high field PID readings were noted in BH08, suggesting that VOC contamination may be in a soil gas vapor phase and is not adhering to the soil matrix.

Groundwater monitoring conducted from the three shallow monitoring wells and one deep well noted water quality in both aquifers that met groundwater MSC for industrial use criteria. However, two contaminants were noted, one each in MW07 and MW08, that will require additional evaluation:

1. One SVOC TIC, designated as hydrocarbon oil, was detected at a low concentration in MW07. No oily sheen was observed during sampling and subsurface soil samples taken from BH07 did not show any signs of a petroleum release. Therefore, additional water sampling should be conducted to confirm this condition; however, no additional cleanup measure is warranted if groundwater aerobic conditions prevail.
2. TCE was detected in MW08 above the groundwater MSC for industrial use. The subsurface soil samples taken from BH08 did show evidence of a petroleum

product release as noted above; therefore, additional sampling should also be conducted to confirm the contaminant concentration and to assist in determining whether natural attenuation will be sufficient to permit site closure.

The deep monitoring well was screened across a fractured shale of the underlying San Angelos aquifer to investigate any potential releases from the base of the on-site silo. Bis(2-ethylhexyl)phthalate was the only organic compound detected and the concentration was well below the groundwater MSC for residential use; therefore, there are no signs of a contaminant release from the silo base to the deep aquifer.

## 7.0 RECOMMENDATIONS

---

Based on the data, findings, and regulatory compliance review, the following recommendations for AMS No. 7 are presented below. However, regulatory input is encouraged to ensure site closure and remediation efforts are consistent with TNRCC requirements.

1. Remove and properly dispose of local surface contaminants near the incinerator and cooling tower, using field screening and site process knowledge in determining horizontal excavation boundaries. Localized surface contaminant removal near the incinerator and cooling tower will ensure that background standards can be attained without a complex confirmation sampling program. Estimated labor, material, and equipment costs to surface remediate a 10,000 square foot area (100 ft x 100 ft) without demolition debris removal is \$18,000. Therefore, approximately \$46,000 will be required to remediate surface soils near the incinerator and the cooling tower to include confirmation testing and report preparation.
2. Resample all groundwater monitoring wells to confirm contaminant levels. It is essential that low concentrations of trichlorethene (TCE) in MW08 near the cooling tower are confirmed to determine if localized groundwater treatment is required or whether natural attenuation of TCE can be used to satisfactorily attain TNRCC cleanup and risk reduction standard requirements. Aerobic soil and groundwater conditions are essential if natural attenuation is utilized; however, natural groundwater attenuation will likely require property deed restrictions for regulatory site closure. Estimated groundwater resampling labor and direct costs are \$9,500, to include sample analysis, data validation, and report preparation.
3. The previous SI boreholes and monitoring well locations (now abandoned) were not surveyed during the SI. These locations are still observable on-site by the surface grout; therefore, these locations should be surveyed in order that the SI soil and groundwater data can be incorporated into the analytical data collected during the ESI. This should be accomplished before any additional shallow wells are considered following regulatory review of this report. Estimated labor and material costs to complete this task are \$1,000.

## 8.0 REFERENCES

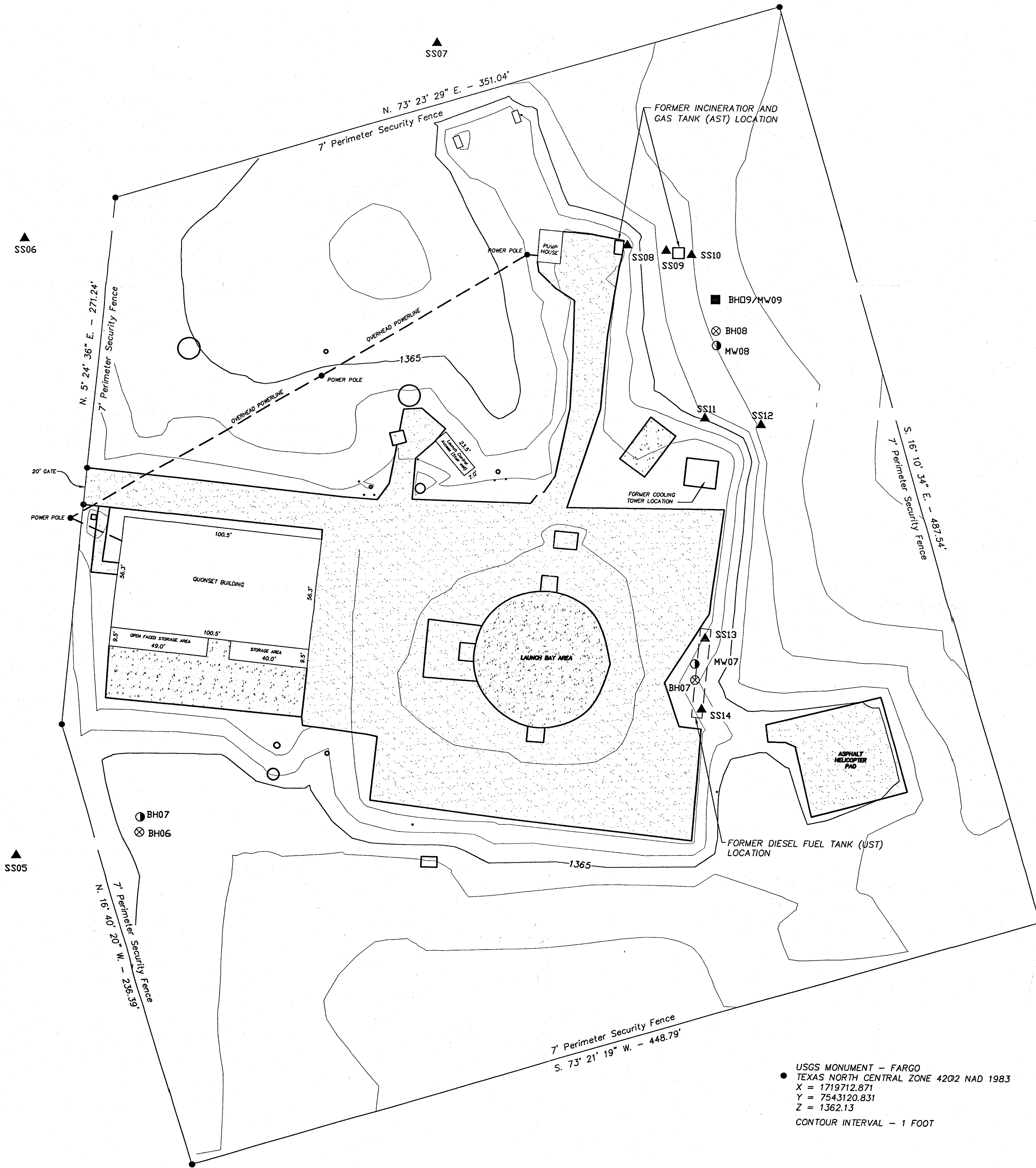
---

- American Society for Testing and Materials (ASTM), 1990. *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*. ASTM D-2488-90.
- Morrison Knudsen (MK), 2000a. *Final Project Closure Report for Atlas Missile Site No. 4, Cache, Oklahoma and Atlas Missile Site No. 7, Vernon, Texas*, prepared for the U.S. Army Corps of Engineers (USACE), Tulsa District (March).
- MK, 2000b. *Final Expanded Site Investigation Work Plan, Former Atlas Missile Site No. 7, Vernon, Texas*, prepared for the USACE, Tulsa District (June).
- Price, R. D., 1979. *Occurrence, Quality and Quantity of Ground Water in Wilbarger County, Texas*, Report 240, published by Texas Department of Water Resources (November).
- Texas Natural Resources Conservation Commission (TNRCC), 1999, *Chapter 335 - Industrial Solid Waste and Municipal Hazardous Waste, Subchapter S* (effective September, 23).
- U.S. Army Corps of Engineers (USACE), 1998. *Site Inspection Final Report, Atlas Missile Site No. 7, Wilbarger County, Texas*, Tulsa district (February).
- U.S. Environmental Protection Agency (EPA), 1994. *CLP National Function Guide for Organic Data Review* (February).
- EPA, 1996. *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, in Ground Water Issue, EPA/540/S-95/504 (April).
- Willis, G. W., and Knowles, 1953. *Ground-Water Resources of the Odell Sand Hills, Wilbarger County, Texas*, published by Texas Board of Water Engineers (January).

| MONITOR WELL TABLE   |            |            |           |
|--|------------|------------|-----------|
| NAME   | NORTHING   | EASTING    | ELEVATION |
| STATE PLANE GRID COORDINATES   |            |            |           |
| MW06   | 7543299.76 | 1719524.64 | 1367.73   |
| MW07   | 7543379.73 | 1719805.65 | 1370.88   |
| MW08   | 7543542.98 | 1719815.49 | 1365.94   |
| MW09   | 7543566.68 | 1719814.85 | 1366.22   |
| NOTE: ELEVATIONS WERE TAKEN AT THE NORTH END OF THE INTERIOR PVC CASING. |            |            |           |

| BORE HOLE TABLE              |            |            |           |
|------------------------------|------------|------------|-----------|
| NAME                         | NORTHING   | EASTING    | ELEVATION |
| STATE PLANE GRID COORDINATES |            |            |           |
| BH06                         | 7543291.90 | 1719524.29 | 1365.0    |
| BH07                         | 7543371.68 | 1719805.76 | 1367.0    |
| BH08                         | 7543550.53 | 1719815.19 | 1362.5    |

| SOIL SAMPLE TABLE            |            |            |           |
|------------------------------|------------|------------|-----------|
| NAME                         | NORTHING   | EASTING    | ELEVATION |
| STATE PLANE GRID COORDINATES |            |            |           |
| SS05                         | 7543279.80 | 1719460.31 | 1366.7    |
| SS06                         | 7543596.67 | 1719463.11 | 1365.6    |
| SS07                         | 7543697.65 | 1719671.36 | 1363.7    |
| SS08                         | 7543594.58 | 1719769.25 | 1366.4    |
| SS09                         | 7543591.92 | 1719789.20 | 1363.8    |
| SS10                         | 7543589.83 | 1719802.20 | 1363.2    |
| SS11                         | 7543505.56 | 1719809.86 | 1364.3    |
| SS12                         | 7543502.42 | 1719838.56 | 1362.9    |
| SS13                         | 7543392.98 | 1719810.79 | 1367.1    |
| SS14                         | 7543356.83 | 1719809.09 | 1366.8    |

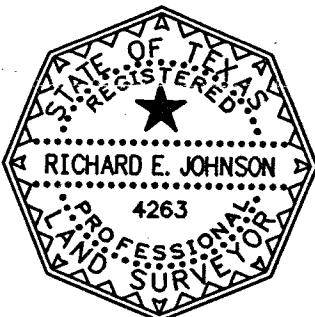


| LEGEND |   |
|--------|---|
|        | ESI SURFACE SOIL SAMPLE LOCATION (ID)           |
|        | ESI SHALLOW BOREHOLE LOCATION (ID)              |
|        | ESI SHALLOW MONITORING WELL LOCATION (ID)       |
|        | ESI DEEP BOREHOLE/MONITORING WELL LOCATION (ID) |
|        | 1365 TOPOGRAPHIC CONTOUR INTERVAL (MSL)         |
|        | CONCRETE  |
|        | ASPHALT   |

NOTE:  
ALL BEARINGS AND DISTANCES ARE STATE PLANE GRID VALUES.

STATE OF TEXAS : KNOW ALL MEN BY THESE PRESENTS,  
COUNTY OF COLLINGSWORTH : that I, Richard E. Johnson, Registered Professional Land Surveyor, do hereby certify that I did cause to be surveyed on the ground the tract of land shown on this plat, and to the best of my knowledge and belief, the said description is true and correct.

IN WITNESS THEREOF, my hand and seal, this the 15th day of August, A.D., 2000.



Richard E. Johnson  
Registered Professional  
Land Surveyor #4263



|  |             |                              |            |
|--|-------------|------------------------------|------------|
| TULSA TERC<br>ESI REPORT<br>FORMER AMS NO. 7 |             |                              |            |
| PLATE 1<br>ESI SAMPLING LOCATIONS            |             |                              |            |
| USACE TULSA DISTRICT                         |             |                              |            |
| MORRISON KNUDSEN CORPORATION                 |             |                              |            |
| FILE NAME (CAD) 2201027.dwg                  |             | DATE: 09/18/00               |            |
| WORK ORDER<br>4423                           | TASK<br>220 | DRAWING NUMBER<br>Figure XXX | REV. DRIVE |